MINERALS AND ENERGY BRANCH

REPORT OF ACTIVITIES

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NOVA SCOTIA
Natural Resources

Honourable Ernest L. Fage
Minister

D.J. Graham
Deputy Minister

Halifax, Nova Scotia
2001

Cover photo

Aerial view looking west (October 2000) of bulk sampling operations at the Black Bull Resources quartz-kaolin deposit located near Flintstone Rock, Yarmouth County. The bright white colour of the rock piles reflects the high purity of the quartz material. The area is underlain by coarse-grained leucomonzogranite of the ca. 370 Ma Davis Lake Pluton, part of the South Mountain Batholith (see p. 37-48 for details), with metasedimentary rocks of the Meguma Group to the south.

Inset shows a close-up of quartz-kaolin rock from one of the trenches excavated in the summer of 1999. The specimen shows brecciated fragments of the host leucomonzogranite, which have been replaced by kaolinite (white mineral) and subsequently cut by multiple veins of quartz. Note the residual grains of primary, magmatic quartz in fragments of altered granite, which represent the only vestige of the original granitic texture.

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Carboniferous Research in the Cumberland Basin, Northern Nova Scotia

J. H. Calder

Introduction

The work summarized here represents field research conducted mainly during 1999 and 2000, and in many cases represents continuing projects. In 2000, the Cumberland Basin of northern Nova Scotia was the main focus of field work and related research. Studies described below, in particular a modern sedimentological description of the Joggins coastal section and the revision and documentation of the macrofloral record of the Cumberland Group, contribute to the scientific accredition of Joggins as a prospective UNESCO World Heritage site (UNESCO, 1972).

Sedimentology and Stratigraphy

Joggins Section (NTS 21H/09)

Research in 2000 focused on specific aspects of the Joggins section, in order to publish the results of projects carried out in collaboration with colleagues Sarah Davies (University of Leicester) and Martin Gibling (Dalhousie University). These projects include: (1) the first comprehensive documentation of the fossil record and its paleoecology since the pioneering work of Dawson (1855, and many others); and (2) the first detailed account of the sedimentology and paleoecology of the renowned fossil lycopsid forests for which Joggins is famous. In addition, the writer entered into formal collaboration as a committee member for M.Sc. thesis research at Dalhousie University by Michael Rygel. This current research centres on the evolution of fluvial architecture recorded in the Joggins Formation.

The focus of field work during 2000, however, was a detailed sedimentological description of the problematic redbeds exposed at Lower Cove, intervening between the Boss Point Formation and overlying coal measures of the Joggins Formation, to which these strata are currently assigned.

Lower Cove Redbeds

The bed-by-bed measurement of strata exposed in the wave-cut platform and bluffs in the 2 km long section of redbeds at Lower Cove, north and south of Little River, was completed in October 2000. This interval, measuring 645 m in thickness, corresponds almost precisely with Division V of Sir William Logan's section (Logan, 1845). The lithologic log of this interval was recorded in the field at a scale of 1:100 and will be digitally transcribed in 2001. The section log adjoins a similar log of the overlying Joggins Formation undertaken by Sarah Davies, University of Leicester, and Martin Gibling, Dalhousie University, thus providing a continuous reference log of the Joggins Formation from South Reef at the upper contact of the Boss Point Formation, to the contact, as presently mapped south of MacCarrons Creek, with the overlying Springhill Mines Formation. This is the first comprehensive log of the 'classic' Joggins section to have been completed since the work of Logan (1845).

Implications

The author concurs with Logan (1845) in according the Lower Cove redbeds a distinct stratigraphic unit (see Calder, 1998, for a review of the history of stratigraphic interpretation of this unit). The Lower Cove redbeds, currently included in the Joggins Formation (Ryan *et al.*, 1990, 1991), are lithologically distinct from overlying strata (Division IV of Logan) which constitute the Joggins coal measures on the strength of numerous attributes including: (1) the absence of coal beds, (2) the virtual absence of grey mudrocks, and (3) the absence of bivalve-bearing limestone beds, all of which are definitive for the Joggins Formation (Ryan *et al.*, 1991). Similarly, they differ from the underlying Boss Point Formation (Division VI of Logan), with its distinctive thick, well sorted, green-grey sandstone bodies, which were quarried for grindstone in the Nineteenth Century.

A proposal to recognize the Lower Cove redbeds as a distinct unit will be made formally in the literature as prescribed by the North American Code of Stratigraphic Nomenclature. Pending demonstration of their regional mapability, these strata may be assigned formation status, which would necessitate redefinition of the Joggins Formation. The Lower Cove beds exhibit many similarities with strata exposed to the west on Marangouin Peninsula, New Brunswick, assigned by New Brunswick workers to the Grande Anse Formation, as confirmed in reconnaissance during the past field season with Susan Johnson of the New Brunswick Department of Natural Resources. Application of this name at Lower Cove may be problematic, however, due to uncertainties in the stratigraphic relationship of the Grand Anse Formation in the type section with neighbouring geologic units, rendered by faulted contacts.

Brule (NTS 11E/14)

Field work at the Brule fossil walchian forest and vertebrate trackway site during 2000 was supported by a grant to the author from the National Geographic Society Research and Exploration Committee, Washington, DC. These funds permitted continued work at the site by colleague Howard van Allen (independant researcher). Our chief focus in the field was the procurement of a reference section cut with a portable rock saw that will be preserved for future study once the site has been eroded, a process well underway. Favourable results revealed aspects of the sedimentology and casting of walchian tree stumps that offer important complementary insight to the plan view, bedding-plane exposures that typify the site.

National Geographic Society funds further permitted continuing curation of bedding-plane mosaics lifted from the site, as well as casting of problematic sections difficult to retrieve. The site continues to be productive, yielding important additional trackway specimens and walchian foliage. Additional finds during the past field season include a second large dragonfly wing and new, enigmatic traces of uncertain plant or animal origin. A field trip to the site by the Canadian Paleontology Conference held at Saint Francis Xavier University in August 2000 provided valuable interpretive insight into the paleo-ecology of this unique locality . Further rock cutting of reference sections is planned for the coming field season.

Biostratigraphy

Waugh River, Tatamagouche (NTS 11E/11)

An important macrofloral site was discovered in 2000 by Tatamagouche resident Jennifer Black on the Waugh River at Tatamagouche. The productive strata, redbeds assigned (Ryan *et al.*, 1990) to the Tatamagouche Formation of the Pictou Group, yield as well a significant record of invertebrate and vertebrate trackways. A long-standing biostratigraphic problem in Maritimes Basin geology has been the assignment of a definitive age to redbeds of the Pictou Group, due in particular to the paucity of palynomorphs and to the general scarcity of fossil sites. The Waugh River site provides a diverse macrofloral compression-impression record comprising ferns, pteridosperms, and walchian conifers, unusual in its state of preservation, which allows taxonomic diagnosis at the species level.

Preliminary assessment of the Waugh River macrofloral collection (Table 1) was undertaken by R. H. Wagner, Jardin Paleobotanico de Cordoba, during a visit to Nova Scotia in November 2000, and further work is currently underway on specimens forwarded to Spain. The flora include taxa common to the Dunkard Group flora of the Appalachian and Interior United States and to the mid-Rotliegend flora of Thuringia, Europe. The recorded taxa constrain the age of the strata most closely to the upper Stephanian, specifically the Stephanian B *sensu* the Ste. Etienne type locality, France (R. H. Wagner, personal communication, 2000).

Confirmation of the age of the Tatamagouche Formation redbeds at Waugh River has implications for interpretations of regional stratigraphy and basin history. An upper Stephanian age for the Waugh River redbeds lends support to the inferred age of the Brule fossil locality, near the Carboniferous-Permian boundary, and the probability that redbeds of the Pictou Group extend into the Permian. The definitive age for rocks mapped as the Tatamagouche Formation at Tatamagouche and the utility of the Waugh River floral record enhances the possibility of testing the existence of an intra-Stephanian hiatus in the Maritimes Basin. Although such an unconformity has been demonstrated in western Europe and may be present in North America (Wagner and Winkler Prins, 1991; Wagner and Lyons, 1997), palynostratigraphic studies in Nova Scotia have been unable to resolve adequately the Stephanian stages in Nova Scotia (Graham Dolby, personal communication, 1995). Field reconnaissance of mapped macrofloral localities, particularly within the underlying Balfron Formation, may allow its critical evaluation.

Macrofloral Analysis

Macrofloral collections from the Joggins section (including Don Reid's collection at the Joggins Fossil Centre and the author's (JHC) at NSDNR, Halifax), Spicers Cove section (Fundy Geological Museum, collected by Brian Hebert, and the JHC collection at NSDNR) and the Springhill coalfield (JHC collection at NSDNR) were evaluated by R. H. Wagner for their biostratigraphic potential. Several taxa unrecorded by Bell (1944 and others) and specimens superior to those published in the literature (Bell, 1944, 1966) are represented in these collections. Select specimens are

Table 1. Preliminary floral list from the Waugh River macroflora locality.

Ferns		
	Zygopteridales	
		Danaeites emersonii Lesquereux
	Marattiales	
		Pecopteris lepidorachis Brongniart
		P. of group *arborescens*
Gymnosperms		
	Pteridospermales	
		Alethopteris cf *bohemica* or *zeilleri*
		Dicksonites plueckenetii (von Schlotheim) Sterzel
	Voltziales	
		walchian conifer

being forwarded to Wagner's paleobotanical lab in Cordoba, Spain, for further study and possible inclusion in his report and forthcoming revision of the Riversdale and Cumberland floras, to be published by the Geological Survey of Canada.

The macroflora collections mentioned above have proved important in resolving an important and contentious difficulty in assigning ages to the Carboniferous strata of Nova Scotia, which has had serious implications for the interpretation of basinal history in the Maritimes. These findings will be reported fully by Wagner to the Geological Survey of Canada, but the macroflora are largely consistent with age assignments determined earlier by Dolby (1991 and others; see Calder, 1998 for a full discussion of the biostratigraphic issues involved) and confirm the presence of early Westphalian strata in the Maritimes Basin.

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Stimulating the Mineral Industry with Prospector Assistance

H. V. Donohoe, Jr.

Introduction

The Prospector Assistance Program (PAP) was designed to help prospectors learn prospecting skills, to provide a financial contribution toward working a mineral claim, and to assist in marketing mineral properties. At the same time, the province benefits greatly. More trained people searching for minerals and enhancing the mineral potential of the province mean that the branch can promote more investment in Nova Scotia. Although the idea of prospector assistance is not new, the current program, which began in 1997, is different than previous prospector assistance programs.

History of Prospector Assistance

Prospector assistance programs began in the early 1990s as part of the Canada-Nova Scotia Cooperation Agreement on Mineral Development (CAMD). The Prospectors's Assistance Program under the most recent CAMD (1992-1995) was one of the most popular programs under this agreement and the results were gratifying. There are now more than 640 registered prospectors with approximately 240 companies or individuals holding one or more mineral licenses in the province. Approximately 150 prospectors received assistance grants for work on their properties between 1992 and 1995. During the same time over 200 people took the Basic Prospecting Course and 12 took the first offering of the Advanced Prospecting Course.

The CAMDs also provided limited financial assistance to attend trade shows for marketing mineral properties. Many prospectors attended the Prospectors and Developers Association of Canada meeting in Toronto and were able to interest companies in their properties.

Current Prospector Assistance

The current Prospector Assistance Program builds on the past experience of the CAMDs. Now the Department of Natural Resources has brought together all parts of prospector assistance into one program instead of several. The program is funded by the Canada-Nova Scotia Cooperation Agreement on Economic Diversification, which is jointly administered by the Nova Scotia Department of Economic Development and Tourism, and Atlantic Canada Opportunities Agency (ACOA). The agreement has a value of $600,000 over fours years and will end in the fiscal year 2001-02. Over the life of the program, each of the three components is receiving strong support. Table 1 provides the budget for each component of the program and a comparison with the actual amounts spent.

The Prospector Assistance Program has been successful in obtaining the support of the prospecting community. Shortly after the program was made official in August 1997, the Minerals and Energy Branch hosted a workshop for stakeholders. Representatives of the prospecting community at large, the Prospectors Association of Nova Scotia, the Mining Society of Nova Scotia, and the Chamber of Mineral Resources of Nova Scotia met with branch staff to review the guidelines and operating procedures of the PAP. The department launched the program at the annual Review of Activities in November 1997.

The PAP is administered by a coordinator, Dr. Howard Donohoe, P. Geo., who is assisted by a committee comprising Dr. Michael Cherry, Director of the Mineral and Energy Resources Division, Michael MacDonald, Ron Mills and Paul MacCulloch. This team provides help to prospectors by training them in exploration skills and use of equipment, mentoring them as they make marketing contacts at trade shows and visiting them in the field.

Program Components

The program has three components: (1) prospector training, (2) prospector assistance and (3) marketing assistance. Although each component is independent of the others, all three are integrated in a uniform approach to encouraging the development of the province's mineral potential.

Training Assistance. Prospector training provides support for training entry level prospectors in different locations throughout Nova Scotia. An advanced course is offered as demand warrants and gives additional experience to prospectors who have graduated from the basic course. The demand for training has been great. We have tried to deliver basic prospecting courses in various parts of the province. Since the PAP began in 1997, 289 people have taken the basic and advanced prospecting courses. Graduates rate the course content and the instructors very favourably. Table 2 lists the locations of courses and the number of graduates in the past several years.

Prospector Assistance. Financial assistance under the prospector assistance component provides a base level of support for individual prospectors to search for new mineral deposits and to attract exploration activity by larger companies. Both the PAP and the prospector contribute toward the funding of a project. If a prospector has an application approved for the maximum amount of $5,000, then he or she is required to contribute a minimum of $1,500 or 30% more to the project. Prospectors may choose to pay for some of their out-of-pocket expenses and/or in-kind work for their

Table 1. Budgeted and actual funds for the Prospector Assistance Program.

Component	Year 1 1997-98	Year 2 1998-99	Year 3 1999-00	Year 4 2000-01	Year 5 2001-02	Totals
1. Training						
Budget	$15,000	$25,000	$20,000	$20,000	$0	$80,000
2. Assistance						
Budget	$20,000	$100,000	$140,000	$140,000	$0	$400,000
3. Marketing						
Budget	$30,000	$30,000	$30,000	$30,000	$0	$120,000
Total Budgeted Amount	$65,000	$155,000	$190,000	$190,000	$0	
Total Budgeted Amount of PAP						$600,000
Actual Amount Spent	**$33,380**	**$120,344**	**$197,720**	**$171,162**	**$77,394 (est)**	**$600,000**

Table 2. Location of prospecting courses.

Year	Total Number of Students	Locations of Basic Course	Location of Advanced Course
1997, Fall	30	Port Hawkesbury, Halifax	Not offered
1998, Spring	58	Sydney, Halifax	Halifax
1998, Fall	64	Stellarton, Halifax, Bridgewater	Not offered
1999, Spring	30	Windsor	Stellarton
1999, Fall	45	Halifax, Sydney, Stellarton	Not offered
2000, Spring	30	Halifax	Truro
2000, Fall	32	Sydney, Bridgewater	Windsor
2001, Fall	n/a	Proposed for Yarmouth, Halifax, Sydney	Proposed; Location to be decided

share of the total contribution. Although they only need to contribute a maximum of 30% of the total program amount toward their project, prospectors often contribute considerably more. In Year 2 (fiscal 1998-99) prospectors contributed an additional 57% above the program amount, which is 27% above the minimum amount. In Year 3 (fiscal 1999-00) prospectors have contributed an additional 87% of the program funds (57% above the minimum). During year 4 (fiscal 2000-01) prospectors contributed 66% in additional funds (36% above the minimum required). The modest funding levels for the prospector assistance component are able to leverage a considerable amount of funds from prospectors. The number of projects and their targets are shown in Table 3. The geographic distribution of prospector projects for fiscal year 2000-01 is evenly distributed across the province and is shown in Table 4.

Marketing Assistance. The third component of the PAP is designed to assist in promoting and marketing a prospector's mineral claims. Most marketing work is conducted at national and international trade shows. These provide an unparalleled opening to present Nova Scotia's mineral potential and investment opportunities to mining companies and industry representatives. Marketing assistance for prospectors provides financial assistance to travel to trade shows, to display information and samples about properties, and to make contacts with industry people. Table 5 lists the various trade shows and the number of prospectors attending.

Importance of Prospectors

The reality of today's mineral exploration industry is that prospectors are vitally important. The 'grass roots' of successful mining is having a local community of prospectors involved in searching for new deposits and carrying out exploration on known mineral occurrences. Their work makes mineral occurrences and deposits attractive to investors and mining companies.

Over the past ten years the exploration component of the mineral industry has changed significantly in Canada and Nova Scotia. Most mining and exploration companies have dramatically reduced their exploration staffs and curtailed the resources they would need for exploration. The result is a significant reliance on prospectors to find mineral properties, prospect them, and undertake geological, geochemical and geophysical surveys as needed. At the same time more exploration capital is moving to Central and South America and other parts of the world.

Prospectors have now assumed a stronger role in mineral exploration than they have had previously. They have always been part of the mineral industry at its 'grass roots' but now prospectors are expected to work a property to a higher level of development. The industry's greater reliance on prospectors to do additional work creates a need for training, continuing education, financial assistance and marketing support. The Prospector Assistance Program in Nova Scotia is designed to accomplish all of these.

Measures of Success

Prospectors have been enthusiastic in supporting the PAP. Each of the prospector training courses has been filled and many of the graduates have staked claims. Interest in the prospector assistance contributions was so great in 1998 that we could only fund the first 22 applicants of a total of 36. As many as 80 prospectors will have benefited from prospector assistance contributions to work their mineral claims. From Table 5 it is clear that prospectors have appreciated the support for marketing their properties. During four years of the PAP operation, 61 prospectors have received financial assistance to travel to trade shows and market their mineral properties or products.

Table 3. Summary of prospector assistance component applications.

Calendar Year	PAP Year; Fiscal Year	Number of Prospectors	Target Minerals
1997	Year 1, 1997-98	0	no prospector assistance component funding
1998	Year 2, 1998-99	22	vein and disseminated gold; paleoplacer gold; kaolin; base metals
1999	Year 3, 1999-00	28	vein and disseminated gold; paleoplacer gold; barite/fluorite; base metals; kaolin
2000	Year 4, 2000-01	14	vein and disseminated gold; zinc; paleoplacer gold; base metals; kaolin
2001	Year 5, 2001-02	17, carry-over from year 4	vein and disseminated gold; zinc; paleoplacer gold; base metals; kaolin

Table 4. Prospector assistance component projects by region in Year 4 (fiscal year 2000-01).

Prospector Name	PAP Number	Target Commodity	Property Name
Western Region			
1. Alan Hooper	C00-010	Gold	Whiteburn Gold District
2. Ian Booth	C00-012	Zeolites	North Mountain
3. Charles Banks	C00-014	Tantalum	New Ross area
4. John Wightman	C00-020	Tin and Base Metals	Dominique, near East Kemptville
5. Hubert Burrill	C00-021	Gold	Foote Cove Beach, north of Yarmouth
6. Brian Paul	C00-029	Feldspar	Seffersville, Lunenberg County
7. Lindsay Allen	C00-032	Gold	Mill Village near Bridgewater
8. James Langley	C00-027	Ornamental Stone	Scotts Bay area
9. Henry Bent	C00-015	Rare Earths	Inglisville, Annapolis County
Central Region			
1. Karen McNulty	C00-003	Feldspar	Goodwood near Halifax
2. John MacIsaac	C00-005	Base Metals and Barite	Walton area
3. Andrew Baldwin	C00-006	Base Metals and Barite	Walton region
4. David Hutchings	C00-007	Base Metals and Barite	Walton area
5. Greg Morris	C00-009	Base Metals	Mt. Thom, NE of Truro
6. Anne Banks	C00-016	Gold	Icelander Settlement, Eastern Halifax County
7. Lyndon Jensen	C00-018	Base and Precious Metals	Cumberland Basin
8. Joseph Collier	C00-026	Gold	South Stewiacke River
9. Votix Corporation	C00-033	Barite	Middle Stewiacke area
Eastern Region			
1. Joe Richman	C00-001	Limestone	Creignish Hills
2. Anthony Barrett	C00-002	Limestone and Base Metals	Creignish Hills and Lime Hill
3. Gaye Johnson	C00-008	Base Metals and Gold	MacLeod Brook region, Cape Breton Highlands
4. Diane Smeltzer	C00-011	Andalusite	Lundy, S of Guysborough
5. Steve King	C00-013	Rare Earths	Lower Caledonia, W of Guysborough
6. John Burton	C00-015	Gold	Barachois Brook, SE CB Highlands
7. Clayton Fraser	C00-017	Gold	Barachois Brook, SE CB Highlands
8. Avard Hudgins	C00-019	Gold	Whycocomagh area
9. Thomas Faulkner	C00-024	Gold, Base Metals	Ocean View region, Gabarus Bay
10. Dennis Forgeron	C00-025	Gold, Base Metals	Ocean View region, Gabarus Bay
11. Kevin McAllister	C00-028	Gold	Isaacs Harbour area
12. Scott Grant	C00-030	Gold	Middle River area, Southern Cape Breton Highlands
13. Curran Jensen	C00-034	Gold, Base Metals	Browns Mountain area, W of Antigonish

Table 5. Trade shows attended by prospectors.

Date	Location	Trade Show; Types of Properties	Number of Prospectors
January, 1998 Year 1 1997-98	Vancouver	British Columbia and Yukon Chamber of Mines Cordilleran Roundup; disseminated and vein gold	3
March, 1998 Year 1 1997-98	Toronto	Prospectors and Developers Association of Canada; paleoplacer gold, vein gold, base metals, rare earths	14
January, 1999 Year 2 1998-99	Vancouver	British Columbia and Yukon Chamber of Mines Cordilleran Roundup; paleoplacer gold, barite/fluorite, base metals	4
January, 1999 Year 2 1998-99	Toronto	Landscape Ontario trade show; various styles and sizes of shaped granite cobbles and granite tiles	1
March, 1999 Year 2 1998-99	Toronto	Prospectors and Developers Association of Canada; vein and disseminated gold, base metals, barite	12
June, 1999 Year 3 1999-00	Halifax	Municipal Expo; various styles and sizes of shaped granite cobbles and granite tiles	1
January, 2000 Year 3 1999-00	Vancouver	British Columbia and Yukon Chamber of Mines Cordilleran Roundup; vein gold in former gold districts; paleoplacer gold	4
March, 2000 Year 3 1999-00	Toronto	Prospectors and Developers Association of Canada; vein gold in former gold districts; paleoplacer gold; zinc skarn deposits; sedimentary zinc deposits; base metals	10
March, 2001 Year 4 2000-01	Toronto	Prospectors and Developers Association of Canada; vein gold in former gold districts; paleoplacer gold; rare earths in pegmatite; zinc skarn deposits; sedimentary zinc deposits; base metals	12

Another measure of success is how the mineral industry views the properties offered at various trade shows. Companies from Australia, South Africa, the United States, as well as Canada, have expressed interest in the properties marketed by Nova Scotia prospectors either through the publication *Properties for Option in Nova Scotia* or at trade shows. Some of the interest has resulted in option agreements where additional money is spent on mineral exploration and development.

What does the province get for the modest investment in the PAP? Prospectors locate and define more of the mineral occurrences and deposits in the province. Their work assists the Department of Natural Resources to promote the province's mineral potential and geological environments. If just one prospector's project goes into production, the amount of capital expenditures for infrastructure, wages, taxes and other benefits will dwarf the modest investment of $600,000 from the Prospector Assistance Program by a factor of 50 or more.

Importance of the Program for Nova Scotia

Prospecting is the grass roots of the mineral industry. Without a trained and motivated community of prospectors, many of the mineral deposit discoveries that we need for future production will not be made. In this sense prospectors are the future of the industry.

In Nova Scotia, the Prospector Assistance Program is successfully providing training, financial assistance and marketing assistance. When prospectors succeed in bringing companies to the province for further exploration and development work they are contributing toward economic benefits. If some of these mineral properties are eventually brought into production as mines, then Nova Scotians benefit from the creation of wealth and employment.

Digital Information Services

B. E. Fisher, J. C. Poole, J. D. MacNeil and J. S. Saunders

The Digital Information Services group is responsible for developing and maintaining the Minerals and Energy Branch (MEB) Geographic Information System and associated databases, the NovaScan bibliographic geoscience database, for supplying digital data and services to clients and staff, and for developing the MEB Internet web site. Permanent Digital Information Services staff consist of geologists/GIS specialists Brian Fisher and Jeff Poole, and word processor operator Susan Saunders. Adam Sherry and Megan Surrette, both geology students, were hired to work with the group on a casual basis in 2000, as was Angela Murphy, a planning and land information technology graduate. Geologist/GIS specialist John MacNeil and geologist Miranda Huskins were hired in November to work on the Targeted Geoscience Initative (TGI) project in south-central Cape Breton Island.

Digital Geoscience Data Products

A collection of digital geology maps, databases and images (in DXF, ARC® export, ArcView® shapefiles, TIFF, and JPEG formats in a UTM projection using the NAD27 datum, and in PDF format) on Nova Scotia has been developed and is now on sale through the library and available for free download from the MEB web site at http://www.gov.ns.ca/natr/meb/pub3.htm. The complete list of digital data products available can be seen in Appendix 3. This list can be obtained from the department's Halifax Library or viewed on the MEB web site at http://www.gov.ns.ca/natr/meb/pubshome.htm. A licence agreement is issued with all digital data sets. This agreement allows unrestricted use of the data with the understanding the Department of Natural Resources remains the owner of the data and is not transferring copyright to the owner. Since March 1999, when the data were first made downloadable from the MEB web site, there have been over 10,000 downloads.

Three new digital products were released in 2000:

D00-01 - Geological Map of the Province of Nova Scotia, version 1, 2000, compiled by J. D. Keppie, scale 1: 500 000.

DP 011 - Enhanced Aeromagnetic and Digital Elevation Image of Eastern Nova Scotia, version 1, 2000, M. S. King (25 m x 25 m, 40 m x 40 m, 80 m x 80 m resolutions); and

DP 012 - Claim, Mining Tract and Petroleum Reservation Grids for Claim Reference Maps, Nova Scotia, Version 1, 2000 (distributed by 1:50 000 NTS map sheet).

Four other digital products were updated:

DP 003 - Drillholes Database, Version 2, 2000;

DP 010 - Abandoned Mine Openings Database, Version 2, 2000;

DP 009 - Claim Reference Map Grid, Nova Scotia, Version 2, 2000; and

DC 001 - Complete Set of Nova Scotia Department of Natural Resources Digital Geoscience Data, Version 3, 2000.

Public Access GIS

A Public Access GIS has been developed for use by clients in the department's Halifax library. This is a user-friendly query and display system that uses a customized version of ArcView® to access a variety of geographically referenced digital geoscience data. It can display and query data sets, overlay various themes of geoscience, topographic and land-use information, and plot the resulting colour maps. Version 3 of the Public Access GIS is currently being worked on and will contain many new themes and an improved menu system. This version should be available in 2001.

GIS Development

Digital Information Services staff have been working cooperatively with members of other sections in the branch on several projects. The new 1:500 000 Geology Map of Nova Scotia was released as Map ME 2000-1 and digital product D00-01 in January 2000. In conjunction with the branch's Land-use staff, they have converted the Mineral Resources Land Use (MRLU) Maps for Nova Scotia into digital form. These are currently being checked and will be released as Open File Map ME 2000-3. The Land Designation and Ownership Map was released as Open File Map ME 2000-1.

Work on integrating the Registry of Mineral and Petroleum Titles database into the GIS and automating the production of the Mineral Claims Disposition Map has been completed. Three open files maps were released as a part of this project in the last year: OFM ME 2000-6, Mineral Rights Disposition Map; OFM ME 2000-7, Designated Underground Gas Storage Exploration Areas; and OFM ME 2000-8, Geothermal Resource Areas. A map of Crown limestone areas will be released in 2001. Each of these will be released as a digital product on our web site in 2001 and the databases will be available in version 3 of the Public Access GIS.

Work is continuing on converting the NovaScan database into ArcInfo® format. When completed, the database will be made available in the Public Access GIS and on the Internet in 2001. Thirty of the detailed Faribault Gold District maps were converted into Arc/Info® format and georeferenced by Megan Surrette. These will be released as digital products on our web site in 2001 and included with version 3 of the Public Access GIS. Adam Sherry was hired to digitize several bedrock geology maps that will be used in the new digital compilation being done as part of the branch's Metro Aggregate Project.

Internet Map Projects

Jeff Poole has created several prototype Internet Map Server (IMS) applications, currently running in-house, which will allow our clients to view, query, plot and download digital maps and databases over the Internet. Over the next year Jeff will be committing the majority of his development time to producing an Internet application, using ArcIMS® technology, that will provide the general public with Internet access to our Public Access GIS layers. It is planned that the initial deployment of this application will be in 2001.

South-central Cape Breton Island Project

In the summer of 2000 the Geological Survey of Canada (Atlantic) and the Minerals and Energy Branch were awarded funding under the federal-provincial Targeted Geoscience Initiative (TGI) for a geological mapping project to aid mineral development in south-central Cape Breton Island. As part of this project, the group is responsible for producing a digital compilation of geological data for this area. John MacNeil and Miranda Huskins were hired in November to work exclusively on this project to build databases, digitize maps and develop the digital products that will be produced. We have identified approximately 90 layers that may potentially be included as part of the final products for this project.

Canadian Geoscience Knowledge Network

The Canadian Geoscience Knowledge Network (CGKN) is a collaborative effort between the 12 provincial and territorial geoscience agencies and the Geological Survey of Canada, which operates six offices across Canada. The plan is for the CGKN to be a single window of Internet access to the geoscience holdings of all the surveys. Over the past year Brian Fisher has served on the CGKN steering committee and the data model working group. He has also been working on the metadata catalogue project and the geochemistry online project. Committees working on these two projects plan to have web sites developed and data published on the Internet in 2001.

NovaScan

NovaScan is the bibliographic geoscience database on Nova Scotia and its offshore regions. As of December 31, 2000, the database contained 14,881 DNR records, consisting of 6517 mineral exploration assessment reports, 3535 publications, 2691 open files, 1200 journal literature references, 756 theses, 165 contribution series, 12 digital publications, and 5 outside publications.

NovaScan was updated with 502 new records in year 2000: 121 assessment reports, 173 publications, 183 open files, 24 contribution series, and 1 outside publication.

In 2000, 152 assessment reports were publicly released from confidential status. Each month, a list of open assessment reports was generated from NovaScan, distributed to the DNR Library, the Core Library in Stellarton, and to the three Regional Geologists in Coxheath, Bible Hill and Bridgewater, as well as posted on the MEB web site. Quarterly reports were produced and published in the *Nova Scotia Minerals Update* newsletter, and on the web site. An Assessment Report Index was released during 2000 entitled OFR ME 2000-1: NTS Location, Author and Citation Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports 1996-1999.

In order to provide better service to our staff and clients by allowing Internet access to and searching of the NovaScan database, two independent projects were carried out in 2000. The first project involved downloading the database into the branch GIS and creating geographic boundaries for all Novascan records. When complete, the NovaScan database will be searchable through the Public Access GIS, and also searchable on the Internet. Completion of this project should take place in year 2001.

The second project involved downloading and converting NovaScan records into standard library MARC format, so that they could be loaded into the Provincial Library's Internet-accessible *NcompasS* catalogue database. This catalogue can be accessed at the following address: http://ncompass.library.ns.ca. After selecting your language of choice (English/French), select Nova Scotia Department of Natural Resources from the available catalogue listings, and you will then be able to search all the DNR Library records, including the NovaScan records. As of December 31, 2000, all open NovaScan records were entered into the *NcompasS* database. Newly opened assessment reports are added to the *NcompasS* catalogue on a monthly basis.

Minerals and Energy Branch Web Site

The following publications were posted on our web site in 2000:

Bulletin ME 2, Part II Limestones and Dolomites of Nova Scotia: Antigonish, Guysborough, Pictou and Cumberland Counties, by D. A. Murray.

Bulletin ME 7 Structure of the Canadian Appalachians, by J. D. Keppie.

Economic Geology Series ME 1990-3 Oil Shale Resources of Nova Scotia, by W. D. Smith and R. D. Naylor.

Economic Geology Series ME 1992-1 Various Industrial Mineral Commodities in Nova Scotia, by R. H. MacDonald.

Economic Geology Series ME 1992-2 Aggregate Potential of Cumberland and Colchester Counties, Nova Scotia, by G. Prime.

Information Circular ME 60 Properties for Option in Nova Scotia 2000.

Information Series ME 8 Coal in Nova Scotia, by J. H. Calder.

Nova Scotia Minerals Update
Volume 17, Number 1
Volume 17, Number 2
Volume 17, Number 3
Volume 17, Number 4

Open File Report ME 2000-1 NTS Location, Author and Citation Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports 1996-1999, by P. D. McCulloch, S. Marshall, N. A. Lyttle and J. S. Saunders.

Open File Report ME 2000-3 Limestones and Dolomites of Nova Scotia, Part 3 (Colchester and Halifax Counties), by D. A. Murray.

Report ME 2000-2 Mining Matters for Nova Scotia 2000, ed. D. R. MacDonald.

In addition, major revisions were made to the Virtual Field Trip of the Landscapes of Nova Scotia, by R. R. Stea.

Mercury in Soil Gas, Kejimkujik National Park (NTS 21A/06)

T. A. Goodwin and K. D. Page[1]

Introduction

The loons in Kejimkujik National Park (Fig. 1) have the highest levels of mercury (Hg) of any loon population tested in North America (Environment Canada, 1998). Mercury contamination is thought to have a negative impact on the nesting and hatching success rate of loons. For the past several years, a multi-disciplinary team of research scientists including meteorologists, chemists, biologists, geologists, limnologists, and GIS experts from various levels of government and universities have been studying the potential sources and processes that may account for these anomalous Hg levels.

The objectives of this study are (1) to determine if there is a naturally occurring geological source for the Hg and (2) to assess a relatively new Hg vapor flux sampling technique designed by Quicksilver Systems. To this end, various sample media including rock, soil, till, water, vegetation, and soil gas have been collected in and around the park and tested for Hg. Results for Hg in soil gas are discussed in this paper; results for the other sample media are pending.

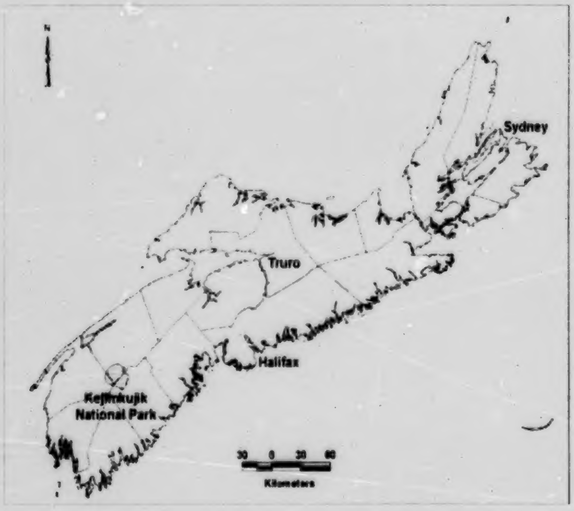

Figure 1. Map of Nova Scotia showing the location of Kejimkujik National Park.

Bedrock Geology

Kejimkujik National Park consists of Cambro-Ordovician metawacke and minor interbedded metasiltstone of the Goldenville Formation overlain by finely laminated slate and metasiltstone of the Halifax Formation (Horne and Corey, 1994). These rocks were intruded by Devono-Carboniferous monzogranite (Scrag Lake Pluton and Kejimkujik Pluton) and leucomonzogranite (Davis Lake Pluton).

Structurally, the metasediments are characterized by a series of northeast-trending anticlines and synclines (Horne and Corey, 1994). Two significant northeast-trending zones of intense, brittle to ductile deformation are inferred to transect the study area, the East Kemptville Shear Zone (EKSZ, Kontak *et al.*, 1986) and the Tobeatic Shear Zone (TSZ, Corey, 1995). The traces of these shear zones, interpreted by the authors from lineaments identified in a 20 m digital shaded relief image, are shown in Figure 2.

Mineralized rocks, including metasediments and intrusives enriched in Au-As-Sn-W-Mo-Cu-Ag-Pb-Zn-Ba, and variably altered (chloritized, silicified, kaolinized, hematized) brecciated boulders, exhibit a strong spatial relationship with known and inferred structures (Horne and Corey, 1994 and Corey, 1995). Corey (1995) suggests that the types and styles of mineralization observed in boulders and diamond-drill core from the Tobeatic Shear Zone are similar to epithermal deposits elsewhere in the world. Epithermal deposits are characterized by the presence of Hg in the form of cinnibar (HgS), among other ore minerals containing Au-Cu-Ag-Pb-Zn-Sb-Se-Bi-U (Evans, 1993).

Surficial Geology

The surficial geology of the study area is characterized by a relatively thin stoney till (Stea *et al.*, 1992). A silty drumlin facies occurs locally, particularly along the eastern edge of the park boundary. The park also features ice-contact glaciofluvial deposits, organic deposits and bedrock-dominated terrain (Stea *et al.*, 1992 and Finck *et al.*, 1994).

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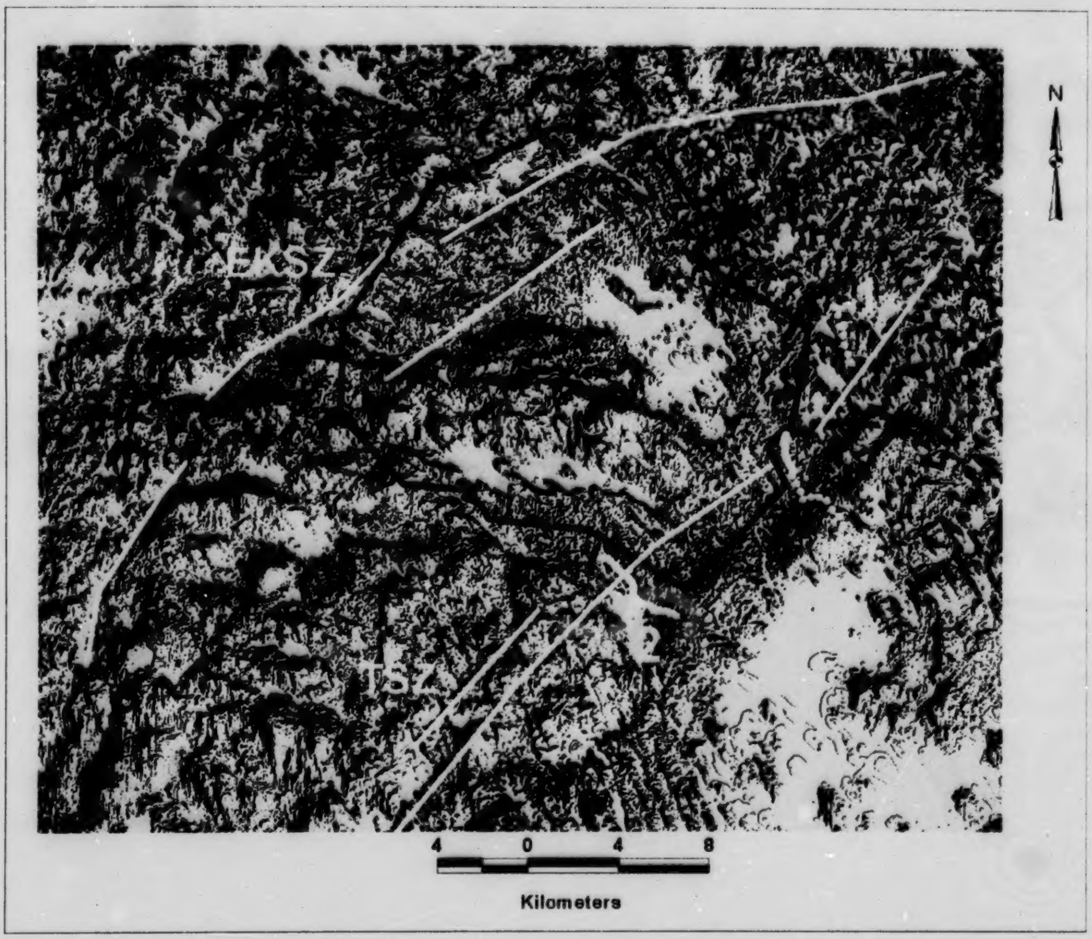

Figure 2. Shaded relief map (azimuth 135°, angle 45°, vertical exaggeration 5x) with inferred locations of the Tobeatic Shear Zone and East Kemptville Shear Zone. Lines 1-4 represent Hg vapor unit sampling locations.

Ice-flow indicators suggest that glacial ice originally flowed to the southwest, then shifted southerly, and finally flowed westward (Stea *et al.*, 1992). Field mapping during the 2000 field season by the authors confirmed the presence of the same three ice-flow directions.

Previous Geochemical Sampling Programs

Nova Scotia has been extensively covered by regional geochemical surveys from various sample media, including vegetation, till, stream sediment, stream water, lake sediment, and lake water. There are no known documented surveys for Hg in soil gas within the province. Only two regional geochemical surveys completed in the Kejimkujik area included analytical tests for Hg: (1) a 1977-1982 till survey, and (2) a 1977-1978 lake sediment survey (Rogers and Lombard, 1990, and references contained therein).

Methodology

Introduction

In September 2000, a total of 94 Quicksilver Hg vapor units were placed along four north-south lines around Kejimkujik National Park (Fig. 3).

Line 1 was designed to: (1) cross the Tobeatic Survey Zone and a doubly plunging anticline, (2) assess the presence of Au associated with the former West Caledonia Gold District, and (3) correlate Hg in soil gas results with till samples collected from the same site.

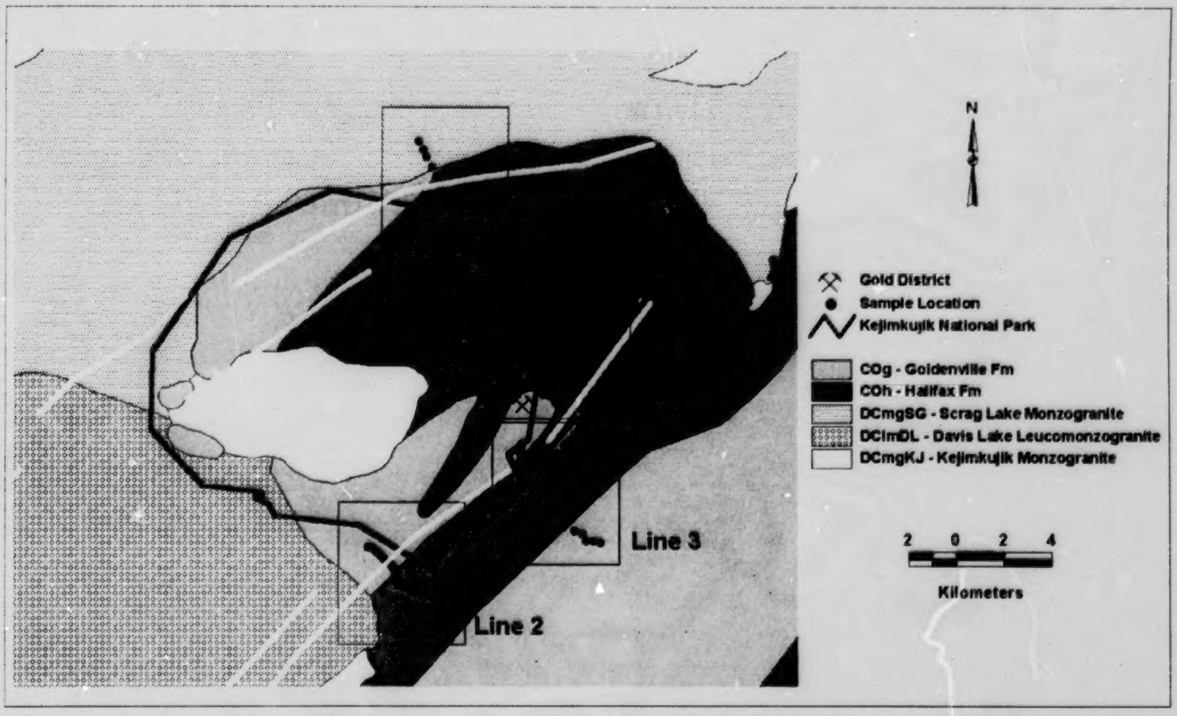

Figure 3. Simplified bedrock geology map with Hg vapor unit sample locations. Enlargements of Lines 1-4 are presented in Figures 5a-d.

The Hg vapor units were placed along a secondary dirt road at a sample spacing of 500 m.

Line 2 was designed to: (1) cross two lithological units (Goldenville and Halifax formations) and (2) cross the Tobeatic Shear Zone. The Hg vapor units were placed along a logging road at variable sample spacings of 100 and 200 m.

Line 3 was designed to: (1) cross two lithological units (Goldenville and Halifax formations), including the Goldenville-Halifax Transition Zone (GHTZ), (2) cross the Tobeatic Shear Zone, and (3) correlate Hg in soil gas results with till samples collected from the same site. The Hg vapor units were placed along a logging road at variable sample spacings of 100, 200 and 500 m.

Line 4 was designed to: (1) cross three lithological units (Scrag Lake pluton, Goldenville and Halifax formations), (2) cross the EKSZ, and (3) correlate Hg in soil gas results with till samples collected from the same site. The Hg vapor units were placed along Highway 8 at a sample spacing of 500 m.

Sampling Methodology

At each sample site, a 30 cm deep hole was dug by hand using a tree-planter style of shovel. The units were assembled at each site and placed at the bottom of the hole. A silver-coloured collector strip was removed from an air-tight glass tube and inserted into a plastic mesh holder (Fig. 4). A 20 cm by 20 cm piece of permeable fiberglass cloth (provided by Quicksilver Systems®) was placed over the cup. The cloth created an air pocket below the unit and provides protection for the unit by reducing soil contact with the collector. Each site was marked with a picket and the sample location was recorded by GPS (Garmin 12). The units were left buried and undisturbed for 30 days.

After 30 days, the Hg collectors were carefully retrieved by digging up each unit. The collector strip was replaced into the air-tight glass tube. The air-tight tubes were immediately sent via courier to Quicksilver Systems® in Bend, Oregon, for Hg analysis.

Analytical Methodology

At the laboratory (cf. Rehn and Rehn, 1996), each collector strip was removed from the air-tight glass tube and sprayed with distilled water in order to rinse off any soil or organic particulate. The strips were dried with lintless paper and placed in a clean glass tube for analysis.

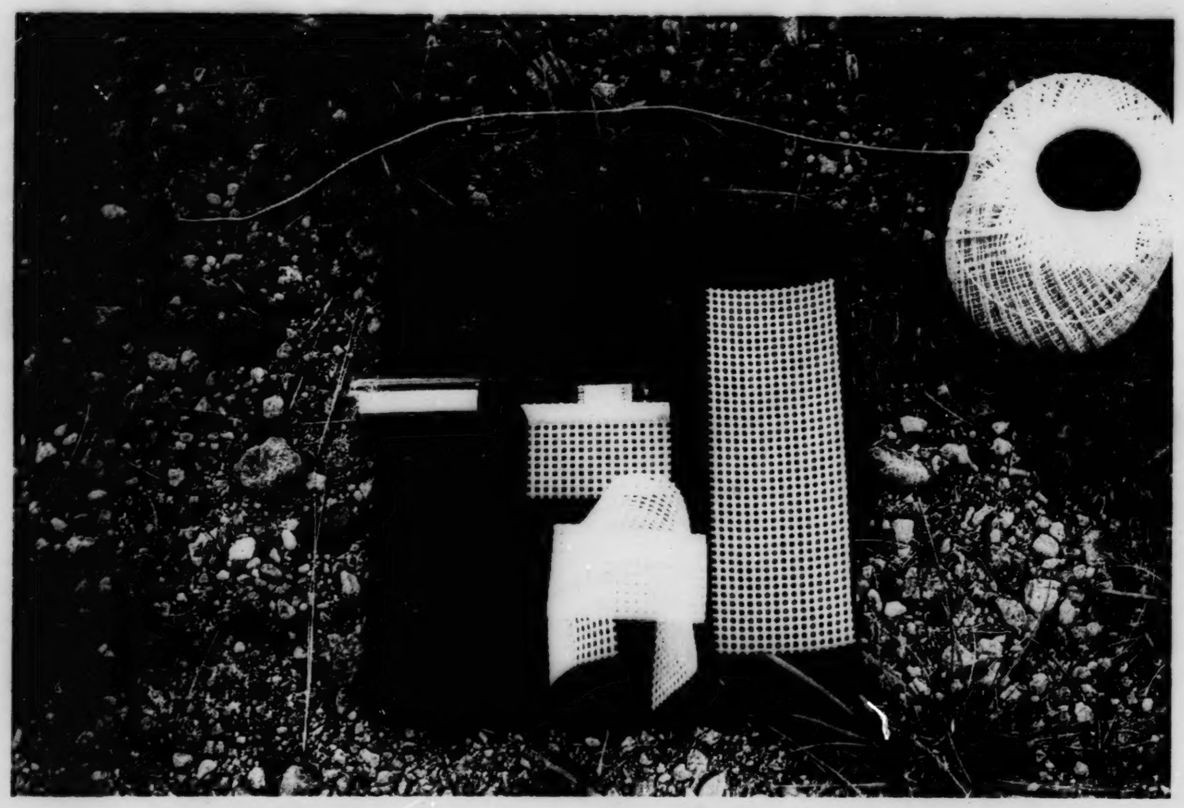

Figure 4. Quicksilver Systems® Hg vapor flux sampling unit showing the silver strip inside the air-tight glass tube, plastic mesh holder, and permeable fiberglass cloth.

The strips were heated to 700°C in a Thermolyne tube furnace, which forces Hg vapor into a stream of air. Mercury is then amalgamated onto a gold foil in a Jerome Gold Film Mercury Vapor Analyzer. Changes in the resistence of the gold foil compared to a reference gold foil represent the concentration of Hg (measured in nanograms). The lower and upper detection limits for the Jerome Vapor Analyzer are 0 nanograms and 100 nanograms, respectively.

Quality Assurance/Quality Control (QA/QC)

Certified reference standards are normally inserted with geochemical samples submitted for analysis in order to assess a laboratory's precision and accuracy. However, no known standards (apart from the previously mentioned reference gold foil) exist for the Quicksilver® Hg vapor units. Therefore, analytical control was limited to four randomly inserted "blank" Hg detection strips, that is, strips that were never buried.

Eleven field duplicates, placed within 1-3 m of the original unit, were used to determine site variance.

Results

Based on the limited Quality Control data (the four blanks and eleven field duplicates), the data are deemed to be of acceptable quality. All four blanks reported 0 ng Hg/strip and the results for field duplicates indicate the samples are representative of the area they were collected from.

The minimum reported Hg in soil gas value is 0 ng Hg/strip and the maximum value is 78 ng Hg/strip ($n = 94$, $\bar{x} = 4.7$, $sd = 9.3$). Based on a review of the data set using (1) a cumulative frequency plot, (2) rank and percentile, and (3) published results by Rehn and Rehn (1996), the authors have determined that background values for this study range from 0-6 ng Hg/strip and that levels ≥ 7 ng Hg/strip are considered anomalous. Apart from two highly anomalous levels (46 and 78 ng Hg/strip) all concentrations range between 0-15 ng Hg/strip. Results for lines 1-4 are presented in Figures 5a-d, respectively.

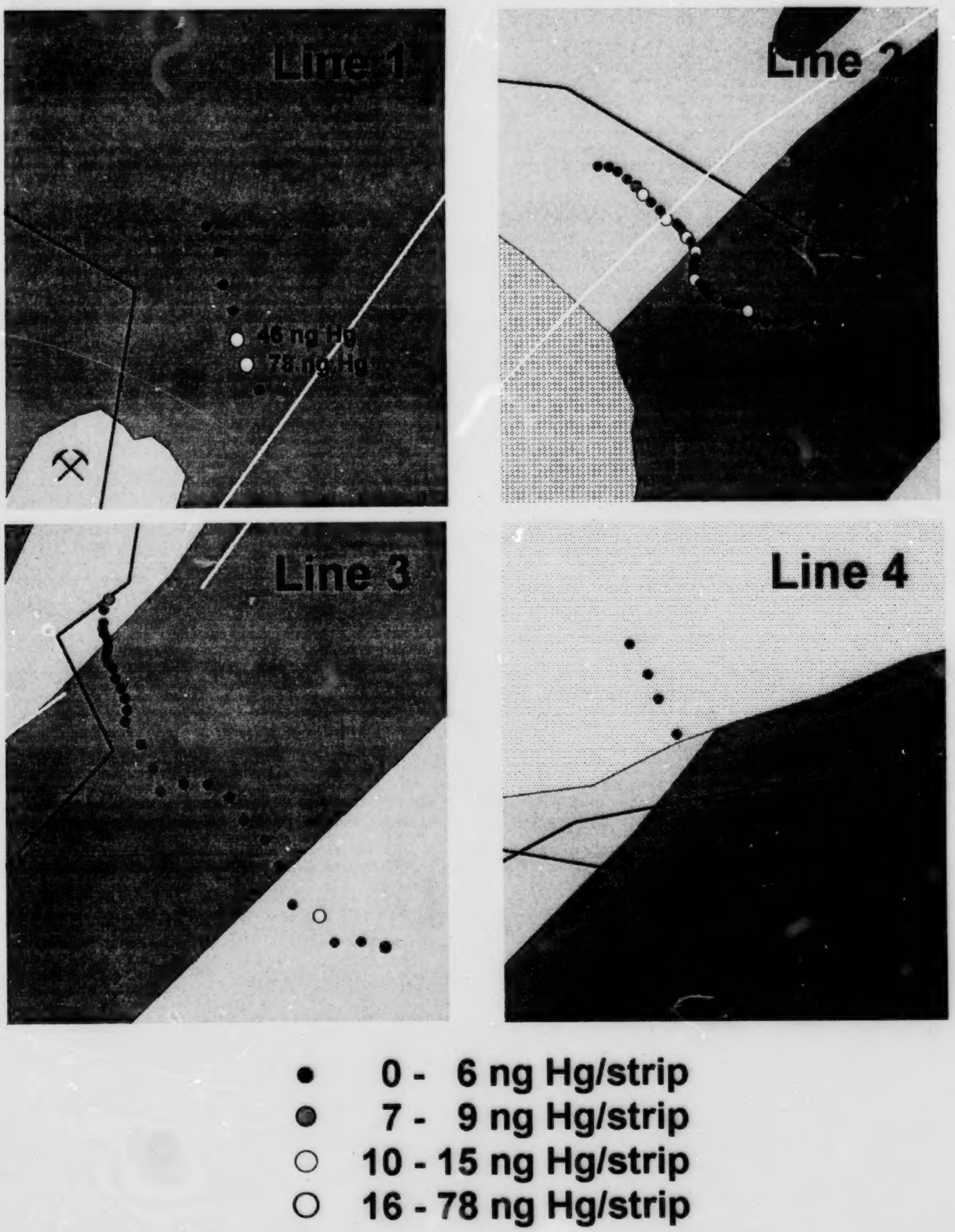
Line 1
46 ng Hg
78 ng Hg
Line 2
Line 3
Line 4
● 0 - 6 ng Hg/strip
● 7 - 9 ng Hg/strip
○ 10 - 15 ng Hg/strip
○ 16 - 78 ng Hg/strip

Figure 5a - 5d. Mercury in soil gas results for Line 1 to Line 4. Refer to Figure 3 for Legend.

Line 1

The highest Hg in soil gas values (46 and 78 ng Hg/strip) reported for this study occur at the southern end of Line 1 (Fig. 5a). The two consecutively spaced samples (500 m apart) were collected approximately 4 km northeast of known Au mineralization associated with the former West Caledonia Gold District. The district is characterized by a pair of doubly plunging, northeast-trending anticlines (Horne and Corey, 1994) and epithermal type textures (P. K. Smith, personal communication, 2000). The two anomalous sample sites are located on the inferred north edge of the Tobeatic Shear Zone.

Line 2

Line 2 (Fig. 5b) is characterized by eight anomalous sites (8-15 ng Hg/strip) that are flanked by at least two background values. This pattern was also noted by Rehn and Rehn (1996) across a drill-inferred, deeply buried (up to 160 m of unconsolidated Quaternary overburden) gold ore body. The eight anomalous sites are spatially associated with the Tobeatic Shear Zone and the inferred structural contact between the Goldenville and Halifax formations.

Line 3

Two single point anomalies (7 and 11 ng Hg/strip) were reported along Line 3 (Fig. 5c), one at the north end of the line and one at the south end of the line. The northern anomalous sample site is spatially associated with the Tobeatic Shear Zone and the inferred structural contact between the Goldenville and Halifax formations. The southern anomalous sample site is spatially associated with the Goldenville-Halifax Transition Zone.

Line 4

There were no anomalous Hg in the soil gas levels reported along Line 4 (Fig. 5d).

Discussion

The data indicate that there is a strong spatial relationship between Tobeatic Shear Zone, and anomalous Hg in the overlying soil gas. Rehn and Rehn (1996) also noted a positive relationship between vertical structures and anomalous Hg in soil gas. The inferred trace of the East Kemptville Shear Zone returned no anomalous Hg levels in the soil gas. The lack of response may be a function of sample distribution, or an absence of Hg in the shear zone at this location.

There also appears to be a positive relationship between the West Caledonia Gold District and anomalous Hg in soil gas.

Conclusions

Results from the 94 Hg vapor units indicate that several local geological sources of mercury potentially exist in the vicinity of Kejimkujik National Park. These sources include inferred structures and the Goldenville-Halifax Transition Zone. Further, the Quicksilver Systems® Hg vapor flux sampling unit is an effective sampling tool for detecting anomalous surface concentrations of Hg vapor produced by bedrock sources.

Further Studies

Results from the Quicksilver® survey will be compared to Hg results reported from the <63 microns fraction of till samples collected from the same sample site approximately one month earlier.

The placement of additional units to further assess site variance will commence early in 2001. This study is also designed to assess temporal variance over a period of several months. Proposed study areas include (1) the site of the highest Hg in soil gas values (46 and 78 ng Hg/strip) and (2) an additional background site for comparative purposes.

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Eastern Shore Compilation Project

L. J. Ham

Introduction

A wealth of information exists in the Nova Scotia Department of Natural Resources (DNR) databases, private research files, and in internal company reports on the numerous gold districts located along the Eastern Shore of Nova Scotia. The first documented gold discovery was in 1858 (Malcolm, 1929). By 1861, several gold-bearing areas (Mooseland, Tangier) were officially declared gold districts and gold had been discovered in a large number of important mining districts throughout the eastern shore. Geological maps were produced early in the twentieth century by E. R. Faribault, and Malcolm wrote a classic memoir on the gold districts in 1929. Since that time, there has been considerable work undertaken by various mineral exploration companies, prospectors, universities and other parties.

As a result, the Eastern Shore Compilation Project was initiated to (1) compile all pre-existing geoscientific information on the gold districts and surrounding areas of the Eastern Shore, (2) incorporate all relevant information on a digital base map with attached databases, and (3) write site-specific deposit reports.

Work thus far on the project has involved deposits on NTS map sheets 11F/03, 04, 05 and 06 (Fig. 1). Field visits were undertaken to the gold districts of Country Harbour, Upper and Lower Seal Harbour, Isaacs Harbour, Wine Harbour (11F/04), Forest Hill and Mile Lake (11F/05) and the tungsten showing at Lazy Head (11F/06; Fig. 2). In addition, numerous smaller showings and occurrences of various commodities were visited. To date, NTS map area 11F/03 has no significant mineral showings reported.

Work in 2000 primarily involved digitizing the early work of Faribault (Faribault map series 25, 26, 27, 29 and 30, Fletcher and Faribault, 1886) and correcting and referencing the work on to the digital bases. The initial work was done in AutoCad® 14 with Fieldlog® 3.4 (for the database component) and then incorporated in ArcView® 3.1 with other information (NSDNR mineral occurrence and drillhole databases) and included with other information currently in digital form (i.e. geophysics). An example of this work is illustrated in Figure 3 and depicts maps 29 and 30 of the Faribault series; the maps have been simplified considerably for the purposes of this report. The other three maps (Faribault maps 25, 26 and 27) that have been digitized and used with this project will be available in the near future. Geological information from other work and sources (e.g. Hill, 1991; Ham, 1988; O'Reilly, 1988; Haynes *et al.*, 1986) was also digitized in AutoCad® and overlain on the information from Faribault. Other geological information, including cross-sections, mine plans and other relevant information, will be incorporated in the digital base maps and databases in the near future. Recent work by the branch's GIS group digitized the individual gold districts and relevant cross-sections from those districts, and this work will also be incorporated.

Highlights of the project and the information found on those maps follow.

Geology

General Geology

The map areas are underlain by metasedimentary rocks of the Goldenville and Halifax formations, with the Goldenville rocks forming anticlines and the Halifax rocks lying in the troughs of synclines (Figs. 2 and 3). The structure of these formations, particularly in the gold district areas, is very complex. Some of the more important geological features in the area include domed anticlines and numerous faults. The majority of anticlines are approximately parallel and vary a great deal in length (from several kilometres to 150 km). In some cases, two anticlines unite to continue as one; others die out but are continued with another anticline formed a short distance away in the same general direction. Anticlines are commonly doubly plunging, have tight to open geometry with steeply dipping fold limbs, and are commonly overturned. Outcrops commonly line up in a series of concentric ellipses or portions of ellipses dominated by meta-sandstone.

Faults

Faults occur both locally and as cross-country faults. Faults generally trend northwest at angles cross-cutting the strike of strata. In gold districts along the Eastern Shore, displacement is to the left (left-hand faults; Malcolm, 1929), whereas in the western portion of the

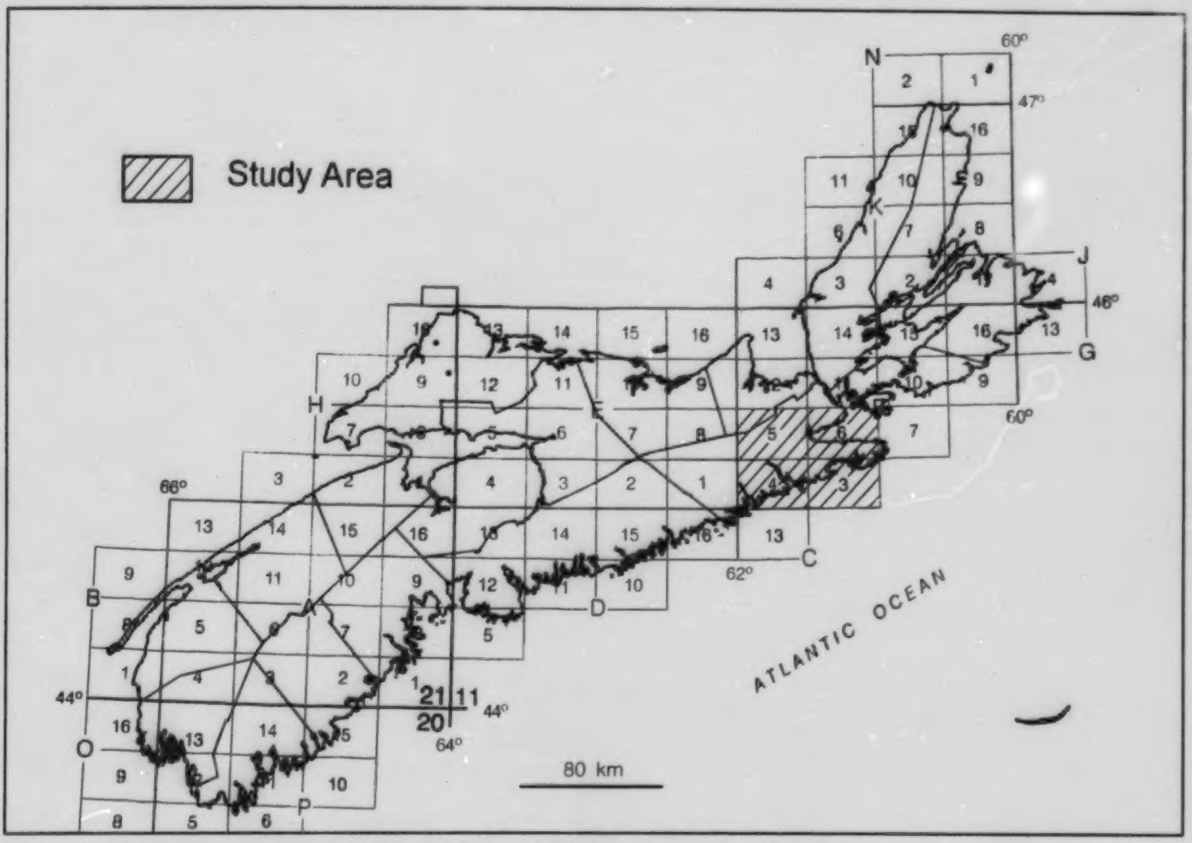

Figure 1. NTS index map of Nova Scotia showing the four NTS areas that were the focus of activity in 2000.

province displacement is to the right. Local faults are found in all gold districts and believed to be related mainly to late-stage doming of the anticlines. These northwest-trending cross-country faults occur on a larger scale, can be traced several kilometres across successive folds, and form a series of breaks that are approximately parallel. Some of the more important faults on these sheets are the New Harbour Fault, with a displacement of ~ 300 m, and the Country Harbour Fault, with a displacement along strike of ~ 2 km (Fig. 3).

Nature of Gold Deposition

Since the discovery of gold and mapping of the gold districts, there has been controversy of the origin of the gold (i.e. whether it was deposited before, during or after regional folding). Today there is still no agreement on the genesis of the gold deposits and the origin of the mineralizing solutions. The location of the gold appears to be determined by some irregularity of rock structure (i.e. it has been suggested that gold occurs where there is a "structure on a structure"; Chatterjee, personal communication). Gold occurs mainly in quartz veins, which generally lie in bedding planes, but gold is also found in veins cross-cutting strike. Quartz veins are found on domes and plunging anticlines and some veins have been traced around the arches of domes from one limb of the anticline to another. Such veins have been mined in the past and current underground work at Dufferin is following some of these 'saddle' veins.

Gold Districts

The individual gold districts that have been the focus of research, in order of production, are: Upper Seal Harbour, Wine Harbour, Isaac Harbour, Lower Seal Harbour, Forest Hills, and Country Harbour. Brief descriptions of each of these districts are included below, and much of these descriptions has been condensed from Malcolm (1929) and other information available in assessment files. All production figures were taken from Bates (1986). Locations for the individual districts is found on Figure 2. Gold districts in Country Harbour, Forest Hill, and Wine Harbour are illustrated on Figure 3.

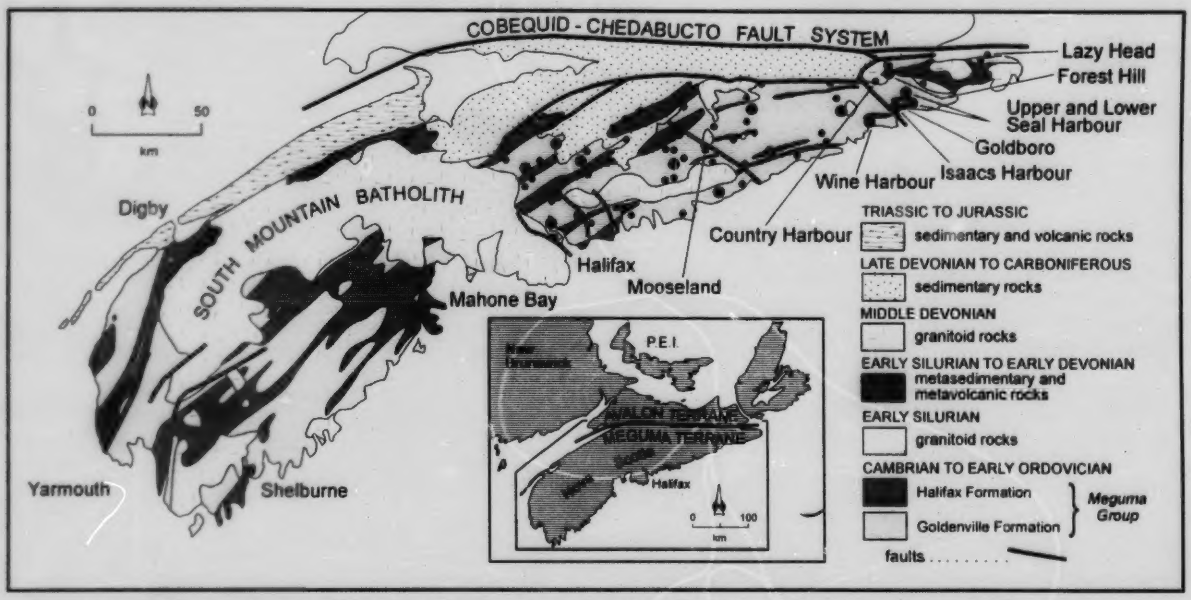
COBEQUID - CHEDABUCTO FAULT SYSTEM
Lazy Head
Forest Hill
Upper and Lower Seal Harbour
Goldboro
Isaacs Harbour
Wine Harbour
Country Harbour
Mooseland
Halifax
Mahone Bay
SOUTH MOUNTAIN BATHOLITH
Digby
Yarmouth
Shelburne
0
50
km
New Brunswick
P.E.I.
AVALON TERRANE
MEGUMA TERRANE
Nova Scotia
Halifax
0
100
km
TRIASSIC TO JURASSIC
sedimentary and volcanic rocks
LATE DEVONIAN TO CARBONIFEROUS
sedimentary rocks
MIDDLE DEVONIAN
granitoid rocks
EARLY SILURIAN TO EARLY DEVONIAN
metasedimentary and metavolcanic rocks
EARLY SILURIAN
granitoid rocks
CAMBRIAN TO EARLY ORDOVICIAN
Halifax Formation
Goldenville Formation
Meguma Group
faults

Figure 2. Simplified geological map of the Meguma Terrane of Nova Scotia, modified after Keppie (2000), showing former gold districts and locations of specific districts discussed in the text.

Upper Seal Harbour

The Goldenville Formation is exposed at this district and folded into a tight anticline that has been affected by three main faults: the eastern, middle and western faults. The veins are interbedded and some attain thicknesses of up to 10 m. The deposit is characterized by large amounts of low-grade ore. Underground workings have uncovered a succession of saddle veins and the richest ore is found in zones on either limb of the anticline close to the anticlinal axis. The Richardson belt was more extensively worked and consists of a belt of quartz and slate lying between walls of quartzite. At the apex of the fold, numerous quartz veins cross-cut the sediments. Total production for this area (1893-1958) was 57,845.7 troy ounces of gold.

Wine Harbour

Gold was first discovered in this district in 1860. The deposit is located on NTS area 11F/04 (Faribault series map 27). The Goldenville Formation at this locality is folded into two anticlines, termed the north anticline and the south anticline (the Wine Harbour anticline; Fig. 3), which converge towards the west. The centre of the dome lies in the west end of the gold district. The south anticline is considered the main anticline, and the north fold is thought to be a crumple on its north limb. A series of radiating faults are found in the southwestern portion of the district. The veins are interbedded and most occur on the south limb of the south anticline. Leads which were initially explored were the Smith, Middle, Major Norton, Barachois, Halliday, Wiscassett and Gillespie leads and other leads developed over time included the Creighton, Hog, Halliday, Desbarres (or Middle), Washington, Air-shaft, Plough, Caledonia, Romkey, Twin, Hamilton, Charlotte, Eureka, Hattie-Mitchell, Moore, McKenzie, Gillis, Mundie, Little South, and McDonald leads. Production at Wine Harbour was reported from 1862-1939 and totalled 42,346.5 troy ounces of gold.

Isaacs Harbour

This deposit is located on NTS map area 11F/04 (Faribault map 27) and was discovered in 1861 by several prospectors who noted similarities in the rocks of this area to the gold-producing rocks area of Wine Harbour. At Isaacs Harbour, the Goldenville Formation is exposed and folded into three parallel anticlines running east and west across Isaacs Harbour (north, middle and south anticlines). The original structure of the fold has been offset by a major northwesterly-trending fault. Several minor faults branch off in a northeasterly direction. The most important leads mined were the Mulgrave, Victoria, Burke and Fraser leads (other leads include the North Star, Grant, Saddle, Little Saddle, McPherson, Hurricane Point, Hattie, Goldfinch leads) on the north anticline. Rich, conformable auriferous veins with gold concentrated in shoots are

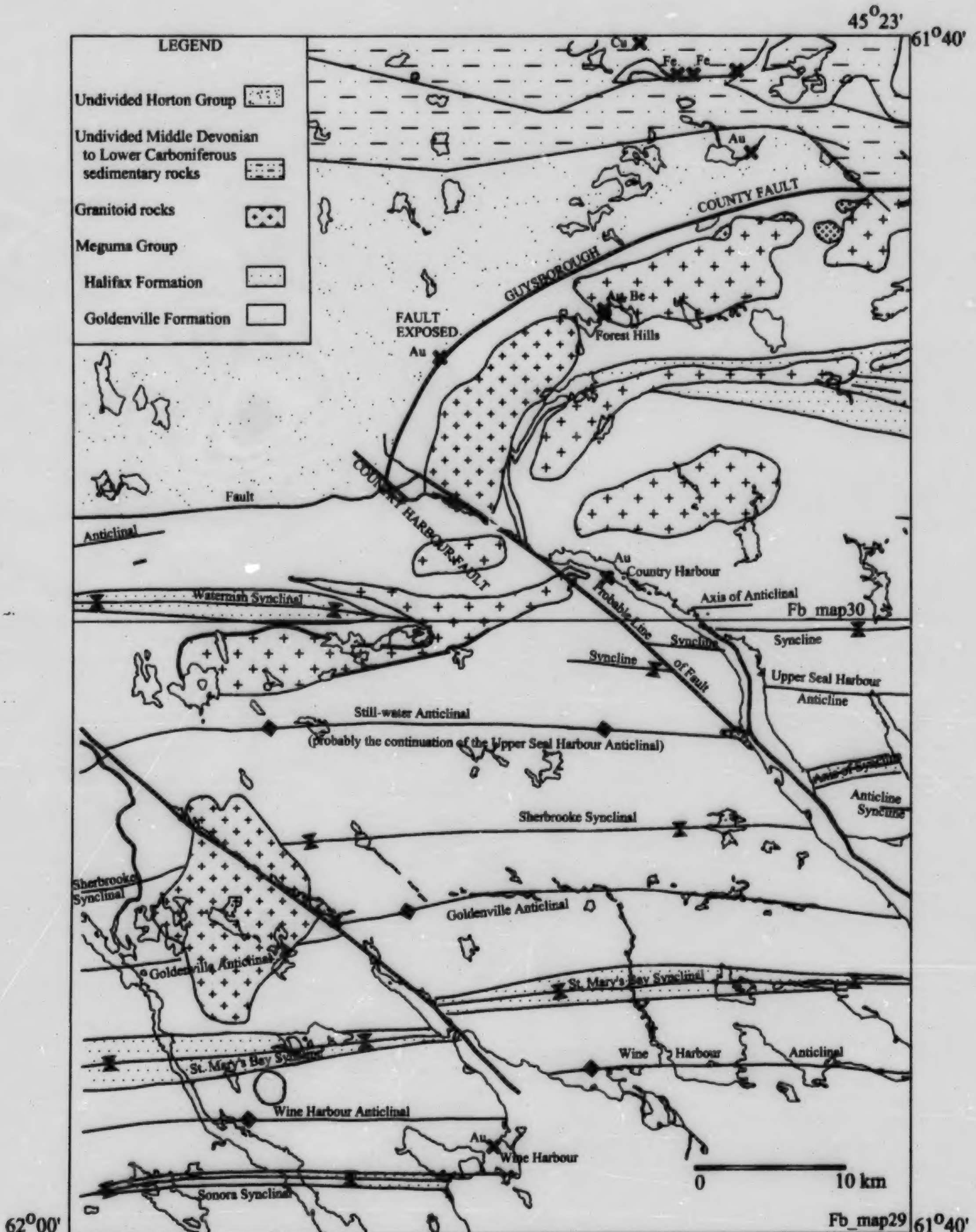
45°23'
61°40'
LEGEND
Undivided Horton Group
Undivided Middle Devonian to Lower Carboniferous sedimentary rocks
Granitoid rocks
Meguma Group
Halifax Formation
Goldenville Formation
Cu
Fe
Fe
Au
GUYSBOROUGH COUNTY FAULT
Au
Be
Forest Hills
FAULT EXPOSED
Au
Fault
COUNTRY HARBOUR FAULT
Anticlinal
Au
Country Harbour
Axis of Anticlinal
Fb_map30
Watermsh Synclinal
Probable Line of Fault
Syncline
Syncline
Syncline
Upper Seal Harbour Anticline
Still-water Anticlinal
(probably the continuation of the Upper Seal Harbour Anticlinal)
Axis of Syncline
Anticline
Syncline
Sherbrooke Synclinal
Sherbrooke Synclinal
Goldenville Anticlinal
Goldenville Anticlinal
St. Mary's Bay Synclinal
St. Mary's Bay Synclinal
Wine Harbour Anticlinal
Wine Harbour Anticlinal
Au
Wine Harbour
0
10 km
Sonora Synclinal
Fb_map29
62°00'
45°08'
45°08'
61°40'

Figure 3. Simplified geological map of Fletcher and Faribault (1886) maps 29 and 30. All information on the original maps is completely digitized and this map illustrates the main geological information. For clarity, all geological symbols and information have been removed.

best developed where the anticline and the syncline converge, forming a crumple. The most profitable portions of the veins can extend over 1 km, are well defined and confined to the crumple. A fault in the eastern portion of the district crosses the anticline and led to the development of the Mulgrave and Mundic leads on the middle anticline; however, the middle and south anticlines were not as well explored or developed. A rich belt (~7 m wide; the Hattie belt) of leads was also developed 300 m south of the middle anticline. This belt is unusual in the respect that the strata curve into a synclinal fold, and is one of the few instances where rich veins have been found in a syncline in Nova Scotia. Production at Isaacs Harbour occurred from 1862-1958 and totalled 39,694.3 troy ounces of gold.

Lower Seal Harbour

This deposit was first worked in 1862, is ~ 4 km east of Isaacs Harbour (Faribault map 27), and lies on the continuation of the Victoria and Goldfinch zone of fissures from that deposit. The Goldenville Formation is exposed and the deposit consists of a wide belt of rock in which numerous quartz veins trending roughly parallel to the bedding are found. Quartz veins also cross-cut bedding in many directions, forming a stockwork of veins. Individual veins are not extensive in either width or depth, and appear to form in an en echelon pattern. Production was reported from 1894-1949 and totalled 34,188.2 troy ounces of gold.

Forest Hill

The Forest Hill deposit was discovered in the early 1890s, and differs from many Meguma deposits because the gold-bearing rocks of this district are adjacent to granite bodies. The Goldenville Formation rocks form a narrow neck with granite to the north and south (Fig. 3). Numerous granitic dykes intrude into the metasediments. The anticline is folded and gently plunging, and the fold axis curves and probably continues into the complexly folded area of the Country Harbour gold district. The richest gold-bearing veins are found on the south limb of the anticline and the most productive leads were the Salmon River, Mill-shaft, Ophir, and Schoolhouse leads (others included the Barrel, McConnell, Fraser, Hudson, Hard, and Camp leads). The production for Forest Hill (1895-1957) was 25,102.4 troy ounces of gold.

Country Harbour

The Country Harbour gold district was one of Nova Scotia's initial discoveries in 1861. The Goldenville Formation rocks are exposed at this locality, and, like the Forest Hill deposit, the district lies in proximity to granite bodies to the east and west, and other granitic bodies occur in the south and southwest (Fig. 3). Numerous granite dykes intersect the metasediments and numerous faults are apparent. The metasedimentary rocks display an unusual north strike, believed to be related to drag on the Country Harbour Fault. The location of the anticline is outlined in outcrop. All the significant ore veins have interbedded geometry and the richest veins lie on the west limb of the anticline. The most important leads of this deposit are the Mason belt and the Prince lode. Production at Country Harbour (1871-1951) was 9959.7 troy ounces of gold.

Further Work

The initial geological base maps are now digitized, corrected and in two separate systems, AutoCad® and ArcView®. The final ArcView® product will be digital maps connected to databases and other information, including cross-sections and photographs. This work will be undertaken in the very near future.

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$^{40}Ar/^{39}Ar$ Dating of Hydrothermal Biotite Associated with High-grade Gold Mineralization in the Whin Vein, Tangier Gold Deposit (NTS 11D/15), Southern Nova Scotia

D. J. Kontak, R. J. Horne, P. K. Smith and D. A. Archibald[1]

Introduction

The origin of vein gold deposits in the Meguma Group of southern Nova Scotia has been a contentious issue for decades, with variations on a metamorphic model being the most common (see review in Sangster, 1990). In these metamorphic models, the age of veining spans the pre-folding, early folding and syn-folding stages of the Meguma Group (e.g. Graves and Zentilli, 1982; Henderson and Henderson, 1986; Henderson *et al.*, 1990; Sangster, 1990) to late in the folding history (Mawer, 1985, 1987; Kontak *et al.*, 1990a, b; Horne and Culshaw, in press). The difference among these various models relates to the timing of vein emplacement with respect to strain history of the host rocks (early versus late). Timing of vein formation can be determined by radiometrically dating vein-forming minerals, thereby determining the absolute age of vein formation. Although a variety of methods may be applied if the appropriate minerals are present (Rb/Sr, Re-Os, Pb-Pb, U/Pb), the most widely applicable is the $^{40}Ar/^{39}Ar$ technique given the abundance of hydrothermal vein micas in many gold districts. Using this method, Kontak *et al.* (1990a, 1993, 1996) dated hydrothermal vein minerals from six gold districts (Fig. 1) and obtained ages of ca. 375 Ma. Of particular relevance is that at one of these deposits (Beaver Dam) concordant ages were obtained for amphibole, muscovite and biotite, which indicates rapid cooling of the area after vein formation given the ca. 200°C range in blocking temperatures for these minerals (McDougall and Harrison, 1988). Thus, the absolute ages so far obtained for the dated gold districts favour the late-stage metamorphic model of auriferous vein formation.

In this paper we report the results of a single $^{40}Ar/^{39}Ar$ analysis of hydrothermal biotite collected from the underground workings of the Tangier gold district. The sample used in this study consists of hydrothermal biotite in the footwall of a high-grade gold vein (Whin Vein; Smith, 2000). Thus, the opportunity to directly date an auriferous vein was presented. What is most significant about this locality is that biotite formation is obviously related to vein emplacement and this vein carries high gold grades. Thus, direct dating of the alteration will provide an age for vein formation which provides at least a maximum age for gold formation, if not the absolute age.

Regional Geology and Nature of Meguma Gold Veins

The Tangier gold district is located 45 km east of Halifax, along the Eastern Shore of southern Nova Scotia (Fig. 1). The area is located within the Meguma Terrane, the most easterly of the terranes comprising the Apallachian orogenic belt, which trends northeastward along the eastern margin of North America. The Meguma Terrane is underlain by two dominant rock units, the lower Paleozoic, metaturbiditic Meguma Group and the ca. 370 Ma peraluminous granitoids that intrude the former. The Meguma Group was deformed and metamorphosed (greenschist facies) into northeast-trending, generally upright, tight to open folds during the Acadian Orogeny, which resulted from accretion of the Meguma Terrane with the Avalon Terrane. The suture zone is now represented by the east-west Cobequid-Chedabucto Fault Zone (Fig. 1). Although the main phase of the Acadian Orogeny has been dated using the whole-rock $^{40}Ar/^{39}Ar$ method at ca. 395 Ma (Keppie and Dallmeyer, 1987; Kontak *et al.*, 1998; Hicks *et al.*, 1999), deformation continued into the Late Devonian, as recorded by syntectonic emplacement of the 370 Ma granites (e.g. Benn *et al.*, 1997, 1998) and offset of contact metamorphic cordierite along folding-related movement horizons in slates adjacent to 370 Ma granites (Horne, 1998; Horne and Culshaw, in press).

Gold districts occur throughout the Meguma Group and consist of bedding-concordant and -discordant veins

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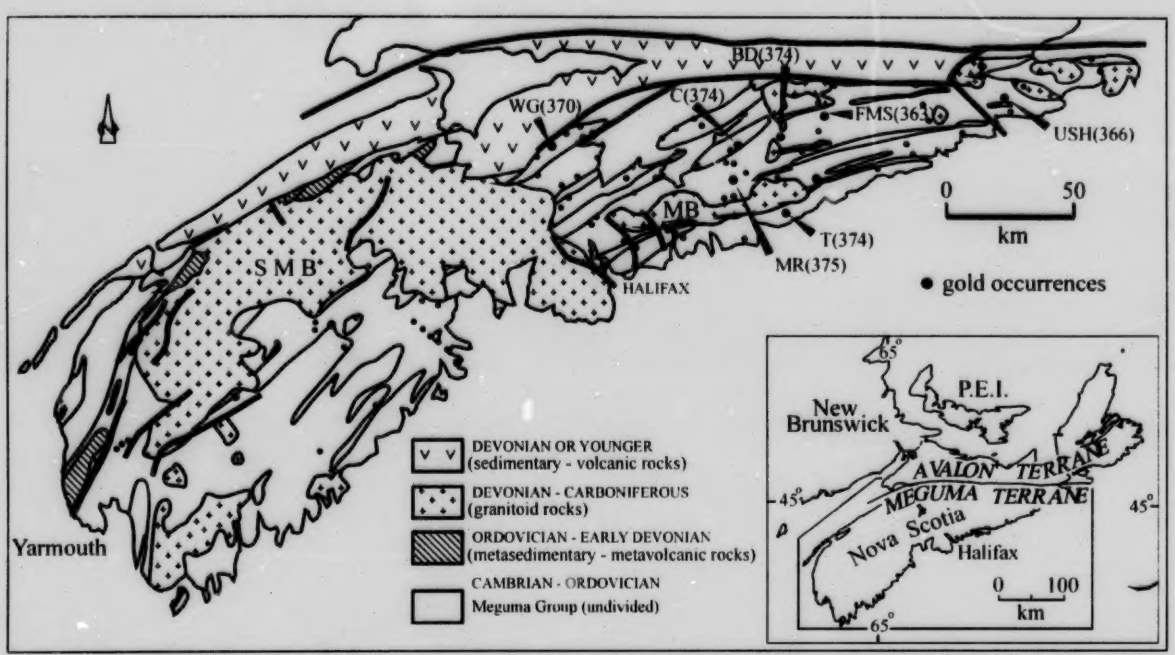
BD(374)
WG(370)
C(374)
FMS(363)
USH(366)
0 50
km
MB
T(374)
MR(375)
S M B
HALIFAX
• gold occurrences
Yarmouth
DEVONIAN OR YOUNGER (sedimentary - volcanic rocks)
DEVONIAN - CARBONIFEROUS (granitoid rocks)
ORDOVICIAN - EARLY DEVONIAN (metasedimentary - metavolcanic rocks)
CAMBRIAN - ORDOVICIAN Meguma Group (undivided)
65°
P.E.I.
New Brunswick
AVALON TERRANE
MEGUMA TERRANE
45°
45°
Nova Scotia
Halifax
0 100
km
65°

Figure 1. Simplified geology of the Meguma Terrane of southern Nova Scotia with location of Meguma gold deposits for which ^{40}Ar/^{39}Ar data are available (Kontak et al., 1990a, 1993, 1996 and this study). Inset box shows the outline of the Meguma and Avalon zones. Abbreviations follow: WG-West Gore, C-Caribou, BD-Beaver Dam, FMS-Fifteen Mile Stream, MR-Moose River, T-Tangier, USH-Upper Seal Harbour, MB-Musquodoboit Batholith, SMB-South Mountain Batholith.

within or near the hinges of regional-scale anticlines. The veins are dominated by quartz, Ca-Mg-Fe-carbonates, and Fe sulphides, may contain laminae of wall-rock material, and are variably folded. The similar setting, paragenesis of vein minerals, fluid chemistry, and wall-rock alteration in gold districts suggest (Smith and Kontak, 1986; Kontak *et al.*, 1990b) a similar origin for many of the gold districts. Although a variety of models exist, we favour a late-stage model for vein emplacement, based on a recent structural analysis of vein emplacement at the Ovens (Horne, 1998). Based on the mutually cross-cutting relationships of concordant and discordant veins, and the formation of concordant veins along movement horizons within slate beds, Horne (1998) concluded that all veins were emplaced during flexural-slip folding late in the folding history of the area. A 376 Ma ^{40}Ar/^{39}Ar muscovite age (Hicks *et al.*, 1999) for mica extracted from pressure shadows around arsenopyrite in the veined area supports this suggested timing of vein formation. Veins at other gold districts are very similar to those at the Ovens (Malcolm, 1929); thus, a similar model for vein emplacement is suggested (Horne and Culshaw, in press). This late vein formation is supported by both relative age relationships and absolute age dating of many gold districts (Kontak *et al.*, 1990a, 1993, 1996).

Tangier Deposit Geology and Sample Description

The Tangier gold district is located ca. 3 km south of the 370 Ma Musquodoboit Batholith (Reynolds *et al.*, 1981; MacDonald and Clarke, 1985) and lies within a package of metasiltstone and slate of the Meguma Group (Fig. 1). The deposit occurs mainly on the southern limb of an upright, northeast-trending (074°) regional fold known as the Tangier-Harrigan Cove anticline (Fig. 2). The fold has a chevron shape, an interlimb angle of 40-50°, and is doubly plunging at 12° away from the district. Local stratigraphy consists of interbedded sandstone, siltstone and shale. Both bedding-concordant and -discordant quartz veins occur with concordant veins preferentially in shale beds. Veins have been traced along strike for ca. 3 km and some 15 major bedding-concordant vein systems occur on the southern limb of the fold (Fig. 2). The most recent studies of the deposit are those of Corey and Mills (1992), who examined the mine stratigraphy, vein mineralogy, alteration and lithogeo-chemistry, and Smith (2000), who examined the grade and distribution of gold within part of the workings (i.e. Whin Vein). These studies indicate that the Tangier deposit has many features common to other Meguma vein gold systems.

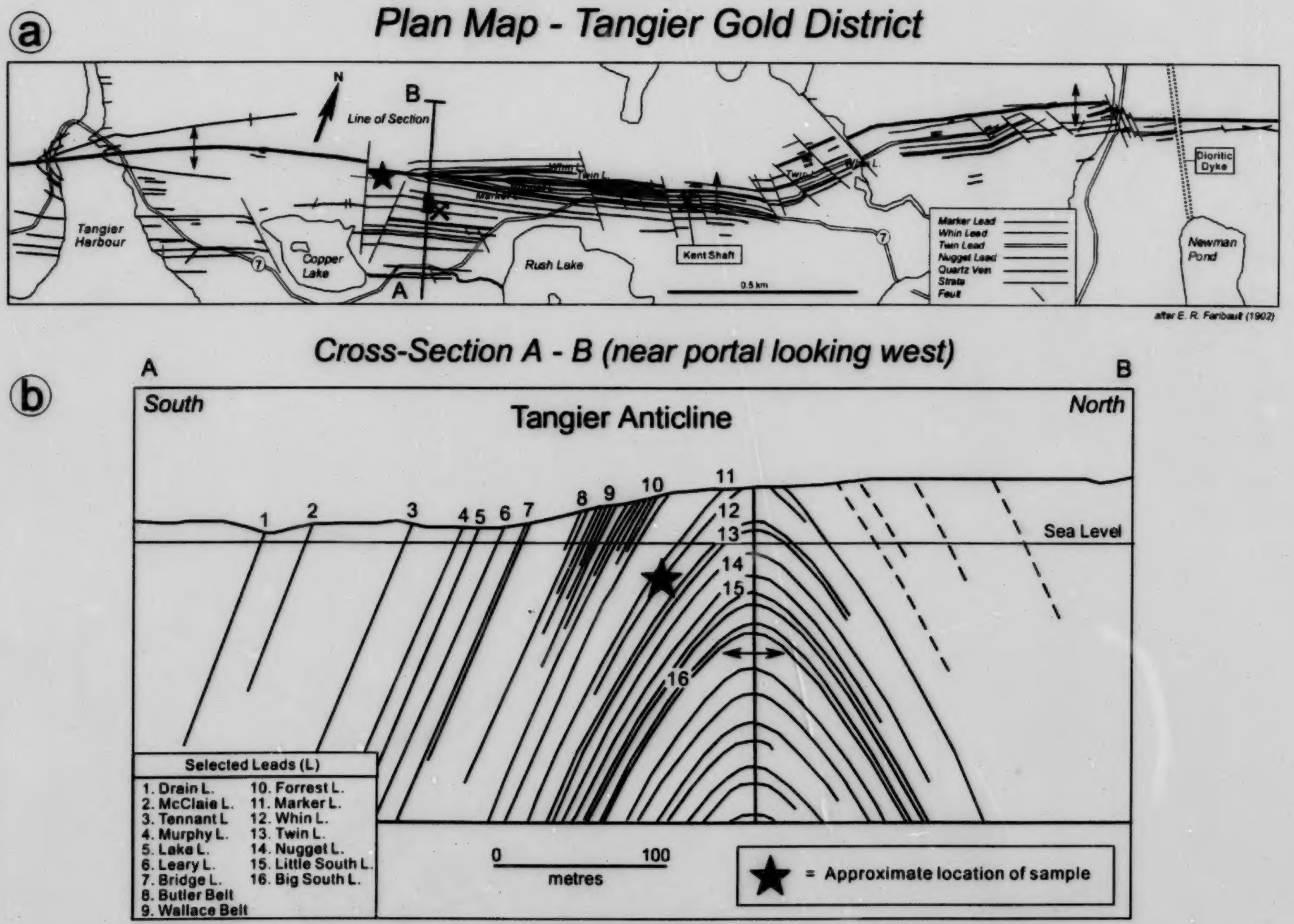
a
Plan Map - Tangier Gold District
N
B
Line of Section
A
Tangier Harbour
Copper Lake
Rush Lake
Kent Shaft
0.5 km
Whin L.
Twin L.
Marker L.
Newman Pond
Dioritic Dyke
7
Marker Lead
Whin Lead
Twin Lead
Nugget Lead
Quartz Vein
Strata
Fault
after E. R. Faribault (1902)
b
Cross-Section A - B (near portal looking west)
A
B
South
North
Tangier Anticline
Sea Level
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
Selected Leads (L)
1. Drain L.
2. McClaie L.
3. Tennant L
4. Murphy L.
5. Lake L.
6. Leary L.
7. Bridge L.
8. Butler Belt
9. Wallace Belt
10. Forrest L.
11. Marker L.
12. Whin L.
13. Twin L.
14. Nugget L.
15. Little South L.
16. Big South L.
0
100
metres
★ = Approximate location of sample

Figure 2. Geological map and cross-section of the Tangier deposit area (after Smith, 2000). The area sampled for this study is indicated by the star.

The sample selected for dating came from underground workings of the 12-55 south-drift-west (SDW) heading (Figs. 2, 3), more specifically the Whin Vein or lead. At this locality, the Whin Vein is in the hinge zone of the fold closure in the western part of the shallowly plunging dome. Where sampled, the Whin Vein actually consists of two distinct veins, with the upper vein being thicker (ca. 10-15 cm) and the lower vein thinner (1-2 cm; Fig. 3). The two veins are variably folded, with the various amount of minor folding and differences in wave lengths of the folds reflecting variation in vein thickness (Fig. 3a, b). The veins are cloudy or milky white and have ribbons of wall-rock inclusions and locally well developed crack-seal textures. Arsenopyrite, pyrrhotite and pyrite are locally disseminated within the veins ($\leq$10 %) and minor carbonate and chlorite also occur. Along the western side of the drift, the slate beds adjacent to the lower contact of the Whin Vein contain multi-centimetre thick clots or beds of massive, fine-grained, dark brown biotite with associated coarse clots and platy grains of white to pale pink carbonate and minor pyrite (Fig. 3c). The textural relationship of carbonate to biotite suggests a late paragenesis. Slabs of the biotite-rich rock reveal that the biotite layers are folded, whereas the presence of very small clots of carbonate in the surrounding shale reflects carbonate alteration of the wall rock (Corey and Mills, 1992). The biotite in this sample is interpreted to be of hydrothermal origin, resulting from reaction of the vein-forming fluids with the pelitic wall rock.

Analytical Techniques

A sample of biotite-rich rock was crushed and fragments of biotite were hand picked under the magnification of a binocular microscope. This biotite was further crushed and sieved and a high-quality biotite concentrate produced using standard methods of magnetic separation and heavy liquids. The sample was irradiated along with an intralaboratory standard at the McMaster University nuclear reactor (Hamilton, Ontario). The sample was then analyzed for ^{40}Ar/^{39}Ar dating at the Geochron Laboratory, Queen's University (Kingston, Ontario) using a defocused, 8W Lexel 3500 continuous argon laser. Complete analytical procedures are outlined in Clark *et al.* (1998). Errors for individual steps and the age spectrum plot represent the analytical precision at a 2σ level, assuming the errors in the ages of the flux monitors (i.e. standards) are 0. This is suitable for comparing within-spectrum variation and for determining which steps constitute a plateau. A conservative estimate for the error in the J value is 0.5%.

Biotite gain mounts were used for chemical analysis using a JEOL 722 Superprobe at Dalhousie University

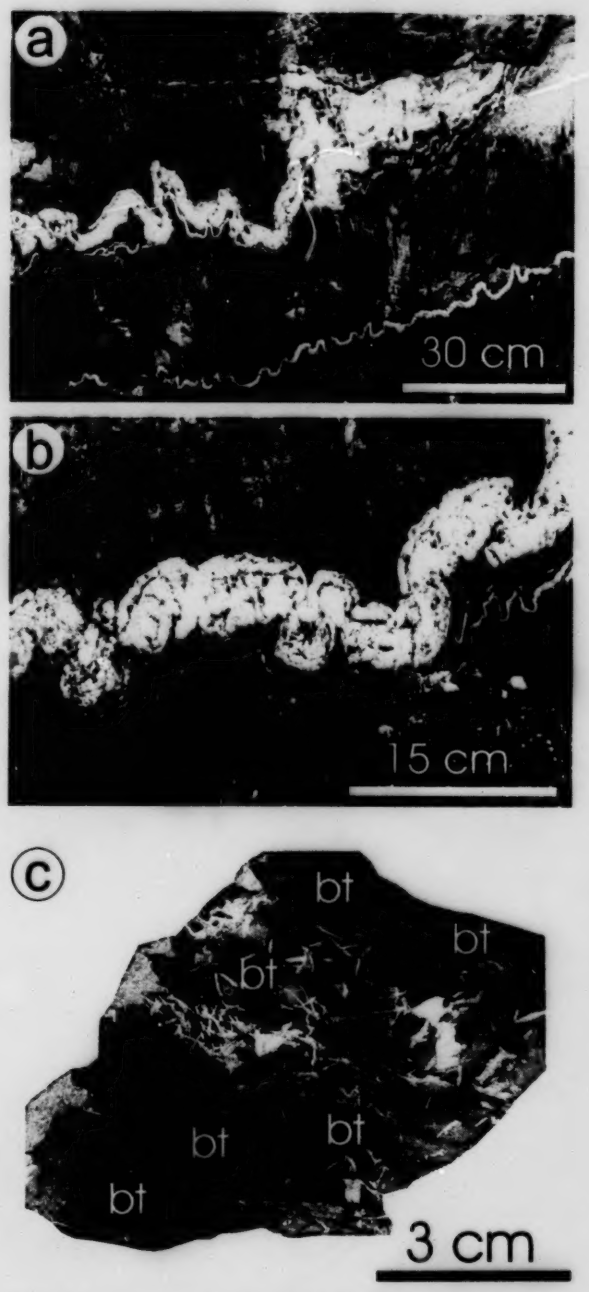

Figure 3. Underground photos (a, b) of the Whin Vein where the sample was collected and slab of the dated sample (c). (a, b) Photographs of the Whin Vein at the face of the 12-55 south-drift west heading (April, 2000) where the gold grade is ore quality (i.e. multi-ounce per tonne, Smith, 2000). Note the vein is in the hinge zone and that in photo b the Upper Whin Vein cuts off the Lower Whin Vein.
(c) Slabbed sample of the biotite-rich alteration that was sampled for dating. The white mineral as clot and plates is carbonate. The darkest material is all biotite (bt) and makes up ca. 50% of the rock sample.

using procedures similar to Kontak and Smith (1993). Several grains were analyzed both in their core and rim in order to see if the biotite was chemically uniform.

Analytical Results

Electron microprobe analysis of several biotite grains indicates compositions typical of hydrothermal biotite in Meguma vein gold deposits (Kontak and Smith, 1993). The Fe/(Fe+Mg) ratios of 0.6 are similar to those in wall-rock biotite at Tangier (Corey and Mills, 1992) and indicate the biotite composition was wall-rock buffered. Low totals and wt.% K_2O levels below those typical of fresh biotite in some of the analyses indicate that some chlorite alteration of biotite occurred in the concentrate.

Results of step-heating experiments on the biotite separate are shown in a conventional argon age spectrum plot in Figure 4a and summarized in Table 1. The data show that the low temperature gas fractions, excluding the first two steps and comprising about 30% of the total gas, define ages of ca. 353 to 363 Ma. In contrast, the higher temperature gas extractions, which include 65% of the total gas, define a plateau age of 373.8 ± 1.7 Ma, which is slightly older than the integrated age of 367.3 ± 3.5 Ma for the sample.

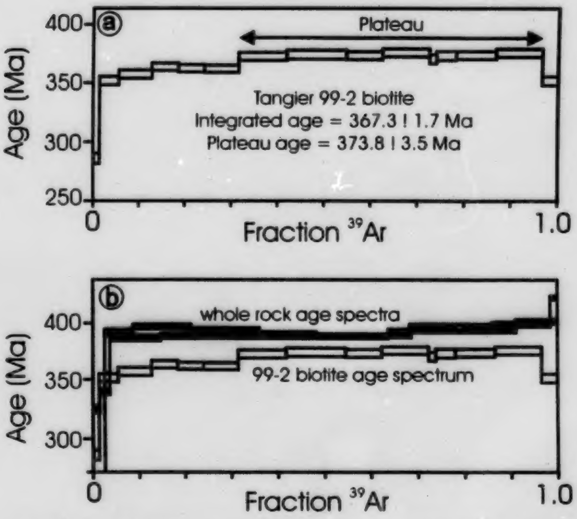

Figure 4. $^{40}Ar/^{39}Ar$ age spectrum plots for samples from the Tangier deposit. (a) Plot for biotite sample dated in this study. (b) Whole-rock slate samples dated by Kontak et al. (1998), compared to the biotite sample dated in this study. Note that samples are all plotted at the same scale and this highlights the difference in age between the whole-rock samples and hydrothermal biotite.

Discussion

The $^{40}Ar/^{39}Ar$ age spectrum for the hydrothermal biotite indicates that this mineral cooled through its ca. 300°C blocking temperature (McDougall and Harrison, 1988) ca. 374 Ma. However, this age contrasts markedly with $^{40}Ar/^{39}Ar$ whole-rock ages of ca. 385 Ma and 392 Ma for ribbon bands of slate in quartz veins from Tangier (Kontak *et al.,* 1998), which are contrasted with the biotite age in Figure 4b. The whole-rock ages have been interpreted to reflect the timing of regional metamorphism in the Meguma Group (Kontak *et al.* (1998). Thus, the contrast between the whole-rock and biotite $^{40}Ar/^{39}Ar$ ages is interpreted to indicate the following important temporal relationships: (1) there was a gap of about 10-15 million years between cessation of regional metamorphism and biotite formation, hence, also vein emplacement; and (2) the Tangier area must have cooled below ca. 300°C, the blocking temperature of biotite, prior to vein emplacement since biotite is an important constituent of the whole-rock samples dated. Locally temperatures exceeded ca. 400°C (e.g. fluid inclusion data; unpublished data of Kontak) during vein formation when the hydrothermal biotite formed. In addition, the similarity in age between formation of vein biotite and emplacement of the Musquodoboit Batholith is not related to resetting of the vein biotite due to thermal influence of the batholith since the whole-rock samples should also have been affected. This conclusion is also supported by the lack of any textural features in the rocks that would indicate contact metamorphism had affected the area. We conclude, therefore, that the 374 Ma plateau age reflects the primary cooling of the hydrothermal biotite through 300°C and dates the formation of auriferous quartz veins.

The 374 Ma age for the Tangier deposit is similar to $^{40}Ar/^{39}Ar$ ages obtained for six other Meguma gold districts (Fig. 1) and collectively the geochronological data indicate vein emplacement was essentially coincident over the eastern Meguma Terrane. Some authors have noted that this age is similar to the age of granites in the Meguma Zone and that thermal resetting must be considered (e.g. Sangster, 1990, 1991; Henderson *et al.,* 1991). However, two points mitigate against this argument, namely: (1) the ca. 375 Ma ages are for deposits both proximal to (i.e. Beaver Dam, Fifteen Mile Stream, Tangier) and distal from (West Gore, Upper Seal Harbour, Moose River, Caribou) the granites; and (2) the $^{40}Ar/^{39}Ar$ ages for samples of slate extracted from gold veins retain older ages that reflect regional metamorphism rather than a thermal influence related to granite emplacement (Kontak *et al.,* 1998). Thus, the apparent ages of the gold deposits are most compatible with the recent inference of Horne and

Table 1. Results of step-heating experiments on the biotite separate.

Isotope Ratios									
Step	$^{40}Ar/^{39}Ar$	$^{38}Ar/^{39}$	$^{37}Ar/^{39}Ar$	$^{36}Ar/^{39}Ar$	Ca/K	^{40}Ar atmos. (%)	^{39}Ar rad. (%)	$^{40}Ar/^{39}Ar_K$	Age
1	22.393±0.015	0.042±0.205	0.011±0.436	0.025±0.199	0.045	20.11	0.25	18.502±1.560	236.21±18.67
2	23.125±0.006	0.020±0.112	0.002±0.590	0.005±0.240	0.009	3.51	1.28	22.582±0.377	284.39±4.39
3	28.595±0.006	0.017±0.103	0.001±0.724	0.002±0.490	0.015	1.21	4.19	28.482±0.321	351.86±3.60
4	28.949±0.006	0.016±0.106	0.001±0.823	0.001±0.760	0.012	0.67	7.1	28.970±0.306	357.33±3.43
5	29.444±0.006	0.015±0.147	0.001±0.712	0.001±0.691	0.014	0.54	5.76	29.512±0.284	363.38±3.16
6	29.331±0.006	0.016±0.117	0.001±0.711	0.001±0.689	0.012	0.5	5.67	29.412±0.270	262.27±3.01
7	29.308±0.006	0.016±0.109	0.001±0.870	0.001±0.716	0.013	0.54	7.35	29.369±0.268	361.79±2.99
8	30.142±0.006	0.015±0.123	0.001±1.056	0.000±1.873	0.012	0.15	10.33	30.311±0.306	372.27±3.39
9	30.305±0.006	0.014±0.136	0.001±1.050	0.000±2.283	0.011	0.19	12.75	30.459±0.345	373.92±3.83
10	30.280±0.006	0.014±0.141	0.001±0.710	0.001±0.965	0.018	0.43	7.83	30.373±0.294	372.96±3.26
11	30.397±0.006	0.014±0.108	0.001±0.856	0.000±2.135	0.011	0.08	10.01	30.593±0.292	375.40±3.23
12	29.843±0.006	0.016±0.153	0.002±0.466	0.002±0.455	0.009	0.23	1.47	30.126±0.337	370.21±3.74
13	30.226±0.006	0.015±0.160	0.001±0.619	0.001±0.937	0.016	0.3	4.12	30.390±0.330	373.15±3.65
14	30.247±0.006	0.015±0.154	0.001±1.070	0.001±1.575	0.014	0.15	8.61	30.423±0.305	373.51±3.38
15	30.386±0.006	0.015±0.104	0.001±0.925	0.000±2.008	0.015	0.07	9.9	30.584±0.296	375.30±3.27
16	28.327±0.006	0.019±0.107	0.001±0.639	0.001±0.731	0.013	0.4	3.39	28.464±0.336	351.66±66.37

Culshaw (in press) that veins were emplaced during late-stage, brittle-ductile re-activation of the regional fold belt.

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Preliminary Fluid Inclusion and Oxygen Isotope Studies of the Flintstone Rock (NTS 21A/04) Silica-clay Deposit, Yarmouth County, Nova Scotia

D. J. Kontak and K. Kyzer[1]

Introduction and Previous Work

Drilling by Shell Canada Resources Ltd. in 1980 and 1982, part of a regional exploration program for tin and base metals in southwestern Nova Scotia, delineated several brittle-ductile deformation zones with associated intense silicification and kaolinite mineralization. One of these areas, Flintstone Rock, is now the site of Black Bull Resources' silica-clay deposit (Fig. 1). Smith (1985) noted that a 10 km long by ca. 1.5 km wide zone of intense deformation containing silica and kaolinite occurred along the southern contact of the South Mountain Batholith (SMB), both within granite and metasedimentary rock. Smith (1985) referred to this as the Rushmere Lake Shear Zone. Subsequently, Giles (1985) included the area in his Tobeatic Shear Zone, a structure proposed to accommodate some existing geological features in the SMB and Carboniferous basins in central mainland Nova Scotia. Ham and MacDonald (1994) showed the location of diamond-drill holes containing quartz-kaolinite and the strike extent of the shear zone in their regional map of the Wentworth Lake area. O'Reilly (personal communication, 1990) and O'Reilly *et al.* (1992) included the area in regional compilations of southwestern Nova Scotia, with an emphasis on the structural and metallogenetic significance of the zone. Finally, Corey and Graves (1996) compiled and described the presence of extensive breccia-hosted Pb-Zn-Ba-Au-Ag occurrences in the eastern extension of this silica-rich shear zone along Little Tobeatic Lake. In addition, these authors suggested an epithermal-type base- and precious-metal model for the shear zone environment.

Over the past two years Black Bull Resources has delineated a zone of 10 km length and 200 m width with a minimum of 100-150 m depth consisting of high-grade quartz-kaolinite. Initial sampling and testing of material has proven to be very promising and presently there are several tens of millions of tons of mineable product delineated (Black Bull Resources update, November 2000). Considering the presence of additional favourable zones along strike from Little Tobeatic Lake to the Rushmere-Moose Fly Lake area in the Tobeatic Fault Zone (Fig. 1), this environment must be considered to have great potential.

The presence of this quartz-kaolinite zone within a fault structure of considerable strike length has important metallogenetic implications for this part of southern Nova Scotia. The recent (1985-1992) production of Sn-Zn-Cu-Ag concentrate from greisen at the East Kemptville deposit, ca. 10 km from the Black Bull site (Fig. 1), established this area as an important granophile domain within the Appalachian region. Analogies to Sn-base metal and kaolinite mineralization in the Hercynian granites of western Europe (i.e. Cornwall, Britanny) are obvious and further indicate the highly favourable potential for more deposits in the area. Consequently, geological studies were undertaken to elucidate the genesis of the quartz-kaolinite and incorporate these results into the existing database for the southwestern Nova Scotia Sn-base metal domain (O'Reilly *et al.*, 1992). This paper reports the results of fluid inclusion and stable isotope studies conducted on materials collected from this site over the past year. Additional work is in progress and, thus, the data presented should be considered preliminary. The aim of the present work is to determine the nature and origin of the mineralizing fluids and interpret these data in the context of a genetic model with implications for the extent of mineralization within the immediate and surrounding area.

Geological Setting

The study area occurs near the contact between granitic rocks of the Davis Lake Pluton (DLP) and metasedimentary rocks of the lower Paleozoic Meguma Group. The DLP, part of the large 370 Ma South Mountain Batholith, is one of several stage 2 intrusions emplaced following intrusion of the earlier granodiorite-

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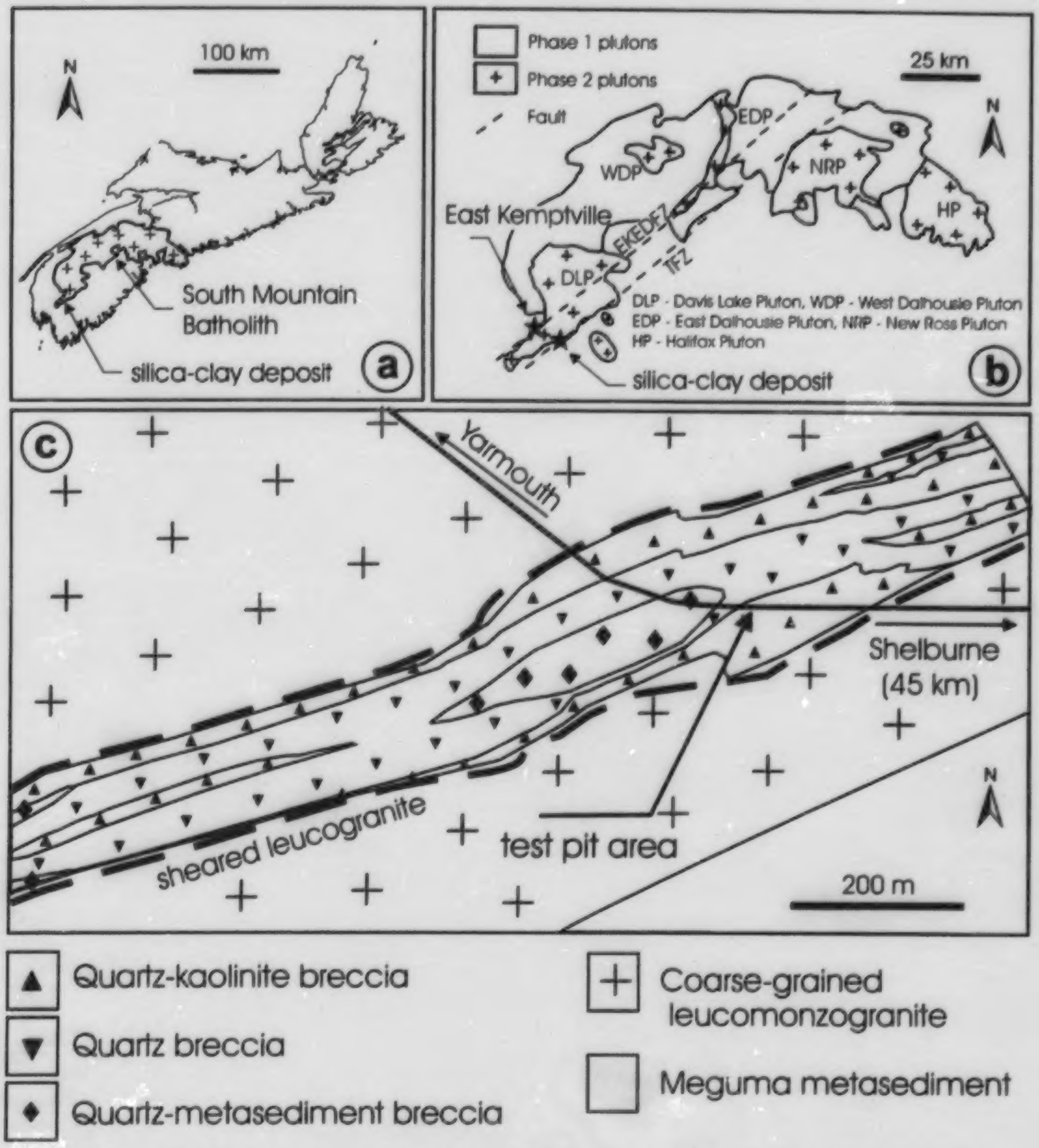
100 km
N
South Mountain Batholith
silica-clay deposit
a
Phase 1 plutons
Phase 2 plutons
Fault
25 km
N
EDP
WDP
NRP
HP
East Kemptville
EKEDFZ
DLP
TFZ
DLP - Davis Lake Pluton, WDP - West Dalhousie Pluton
EDP - East Dalhousie Pluton, NRP - New Ross Pluton
HP - Halifax Pluton
silica-clay deposit
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Yarmouth
Shelburne (45 km)
sheared leucogranite
test pit area
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Quartz-kaolinite breccia
Quartz breccia
Quartz-metasediment breccia
Coarse-grained leucomonzogranite
Meguma metasediment

Figure 1. Regional and local setting of the Black Bull silica-clay deposit, Yarmouth County, Nova Scotia. (a) Regional setting of the deposit area in southwestern Nova Scotia near the southern contact of the 370 Ma South Mountain Batholith (outlined with cross pattern). (b) Geology of the South Mountain Batholith with phase 2 plutons indicated. The silica-clay deposit is located at the southern contact of the Davis Lake Pluton. (c) Geology of the silica-clay deposit (after Black Bull Resources maps). Samples used in the present study come from the test pit area indicated on the map.

monzogranite phases of the batholith. Horne *et al.* (1992) have shown that granite emplacement was controlled by prominent northeast-southwest and northwest-southeast structures; hence, the regionally extensive Tobeatic Fault Zone (Fig. 1b) is considered an earlier structure (i.e. pre- or syn-granite intrusion) and important initially at defining the southern contact of the DLP. In light of the present study it is relevant to note, therefore, that the East Kemptville deposit occurs within another prominent, regionally extensive northeast-trending fault zone (Fig. 1b) that was active at the time of emplacement of the host leucogranite and related greisen-style mineralization (Kontak, 1994; Kontak and Cormier, 1991; Halter *et al.*, 1996).

The Davis Lake Pluton is a zoned intrusion, with relatively primitive phases in the northeast and more evolved phases in the southwest (MacDonald *et al.*, 1992; Dostal and Chatterjee, 1995). The dominant rock type is light-grey to blue-white, coarse-grained, K-feldspar megacrystic leucomonzogranite. Toward the southern contact with quartzite of the Meguma Group, the pluton becomes intensely deformed, with early ductile fabrics overprinted by later brittle features. Within and proximal to this northeast-trending zone of deformation quartz-kaolinite and base metals occur, as noted on the most recent map of the area (Ham and MacDonald, 1994), and also summarized in Smith (1985) and Corey and Graves (1996), in addition to many exploration assessment reports.

The mineral deposit at Flintstone Rock occurs as a ≤200 m wide, northeast-trending fault zone in a strongly deformed part of the Davis Lake Pluton (Fig. 1c). Against the fault zone, coarse-grained leucomonzogranite of the DLP is reduced to ribbon-textured mylonite with C-S fabrics. Similar textures occur in rocks to the southwest (Smith, 1985) and northeast (Corey and Graves, 1996) of this locality. Within the mineralized structure, variably deformed fragments of granite are intensely silicified and/or replaced with bright white kaolinite (Fig. 2a, f). There is a progression from early, very fine-grained, beige to cloudy white silica to later, coarse-grained quartz euhedra (Fig. 2b,d). Quartz veins are common and, again, the early veins are fine-grained and the later ones consist of coarser quartz. Comb textures with vuggy interstitial space suggest that in some cases earlier kaolinite, or some other unknown phase, has been leached (Fig. 2c). Some samples show evidence of periods of brecciation, silicification and cementation. The central silica-rich breccia zone contains the most abundant and coarsest quartz with multi-centimetre size grains present (Fig. 2e). In the latter case, kaolinite may be present as a late stage phase between the coarse quartz euhedra. The mineralized zone consists essentially of quartz and kaolinite in addition to residual muscovite grains and remnant clasts of variably altered granite and metasedimentary rocks; no evidence of sulphides or other minerals (e.g. carbonate, barite) has yet been noted.

Fluid Inclusion Studies

Doubly polished sections (150 μm thick) of quartz-kaolinite material were prepared from eight samples for preliminary fluid inclusion study. Samples varied from very fine-grained quartz (i.e. grain size ≤100-200 μm) to aggregates of coarse euhedral grains. Although the former were inundated with fluid inclusions, in fact so many that they make the samples cloudy, the inclusions were too small (≤1-3 μm) for thermometric study. However, the coarser quartz grains contain abundant fluid inclusions suitable for thermometric study.

Fluid Inclusion Petrography

Petrographic examination of quartz euhedra indicates the following types of inclusions: (1) L-V, (2) L-V-solids, (3) monophase L- and V-rich (Fig. 3). Type 1 inclusions occur as isolated inclusions within quartz, along primary growth zones and healing fracture planes. They are highly variable in terms of size (≤10-30 μm) and their shapes range from equant to irregular. Variable L:V ratios combined with the irregular shapes suggest necking was common, but areas dominated by equant- or regular-shaped inclusions occur rarely. Type 2 inclusions are rare and the solid phase, probably mica and feldspar (?), is considered to represent accidentally trapped inclusions of desegregated granite; no daughter phases (e.g. halite) were observed. Type 3 inclusions are similar to type 1 in terms of size and shape and are the most abundant inclusion type. A large proportion of these inclusions have clearly resulted from necking processes, but it is possible that some actually represent entrapment of L- and V-rich fluids. Further work is required to resolve the origin of these inclusions.

Fluid Inclusion Thermometry

Thermometric measurements were made on two samples of quartz containing type 1 inclusions. Measurements were made with a United States Geological Survey gas flow heating-freezing stage (FLUID INC.) at the Nova Scotia Department of Natural Resources [see Kontak (1998) for details]. The equipment was initially calibrated and is routinely checked with synthetic fluid inclusions. Accuracy for the equipment is estimated at ±0.2°C for low temperature runs and ±1.0°C for high temperature runs, whereas precision determined from replicate runs is ±0.2°C or better.

Inclusions were frozen to -100° to -120°C and heated at a controlled rate while observing the inclusions. During freezing, most inclusions suddenly froze, as recorded by a sudden shrinkage of the vapour bubble, at ca. -35°C, but for some, cooling to -80°C was required. During warming, most inclusions had apparent first melting of -15° to -4°C, but rarely some were near the H_2O-NaCl eutectic of -21°C and others at -1°C. The last melting of ice occurred between -0.5° and +0.2°C. In some inclusions where the vapour phase did not reappear during heating, ice melting temperatures above 0.0°C relate to metastability.

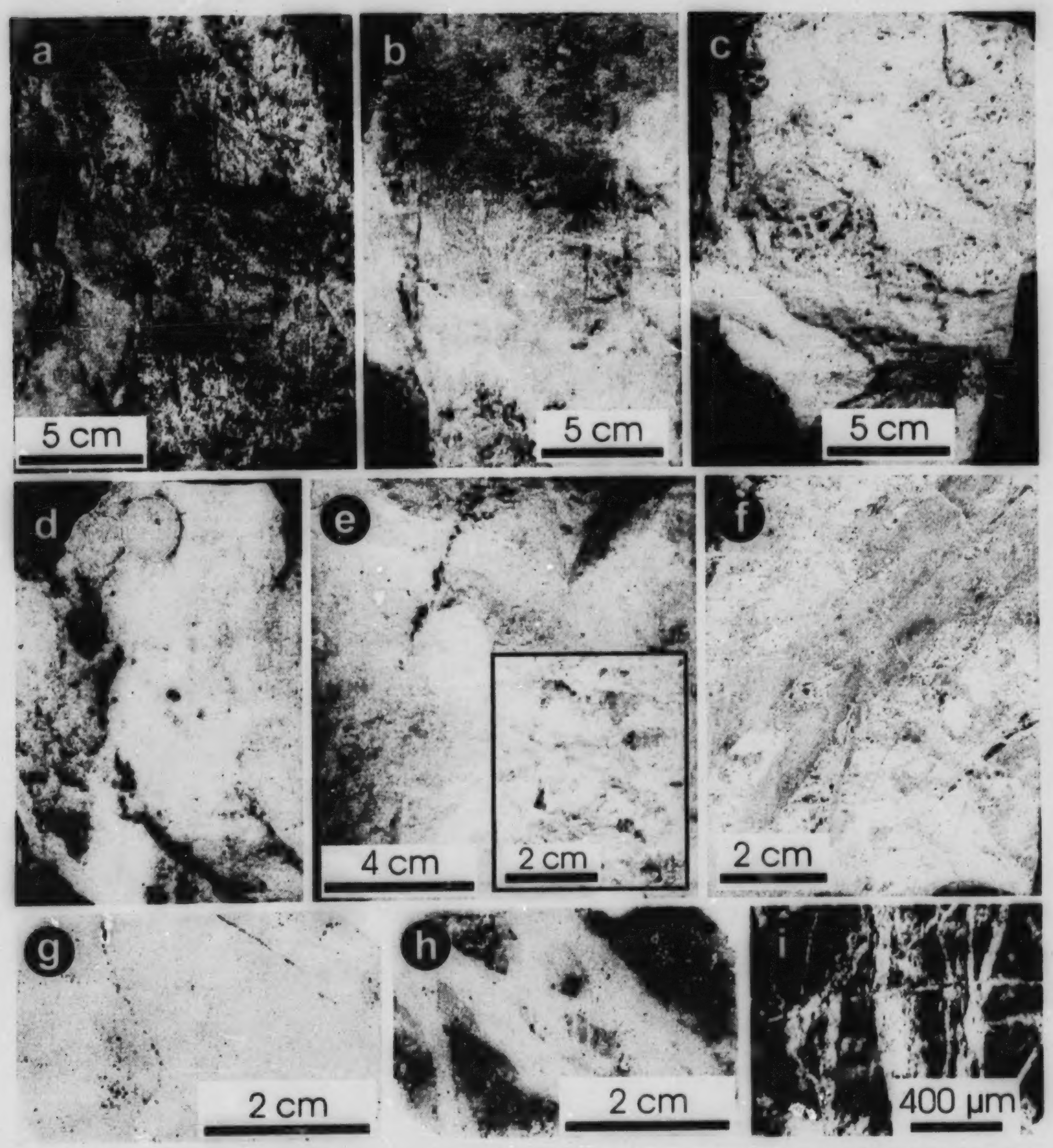

Figure 2. Rock and thin section photos of silica-clay material from Yarmouth deposit area. Note that the term granite in the following descriptions is only generalized and not *sensu stricto.* (a) Fragment of outcrop showing angular pieces of kaolinized granite (white areas) cut by multitude of quartz veins of various orientations and dimensions, but with the latest veins apparently the largest. (b) Remnant pieces of kaolinized and silicified granite (top of photo) but by paragenetically, later cloudy white, fine-grained quartz veins. (c) Remnant, ghost-like pieces of kaolinized and silicified granite with box work texture cut by later, cloudy white quartz veins. (d) Intensely silicified, fine-grained granite cut by later cloudy white quartz veins. Note loonie for scale. (e) A sample of white, fine-grained kaolinite-silica rock (i.e. altered granite) with coarser quartz euhedra throughout (see inset box for enlargement). (f) Multitude of quartz veins cutting kaolinized granite (white areas). Note the fine-grained nature of the quartz veins. (g) Thin section of silicified granite illustrating the very fine-grained nature of the rock and presence of fine veinlets cutting sample, as represented by hairline fractures. (h) Thin section of sample in Figure 2f illustrating the very fine-grained nature of vein quartz. Dark areas are silicified granite fragments with minor kaolinite. (i) Thin section of silicified granite showing the abundance of late quartz veins and the fine-grained nature of the quartz. Dark areas are quartz inundated with fluid inclusions.

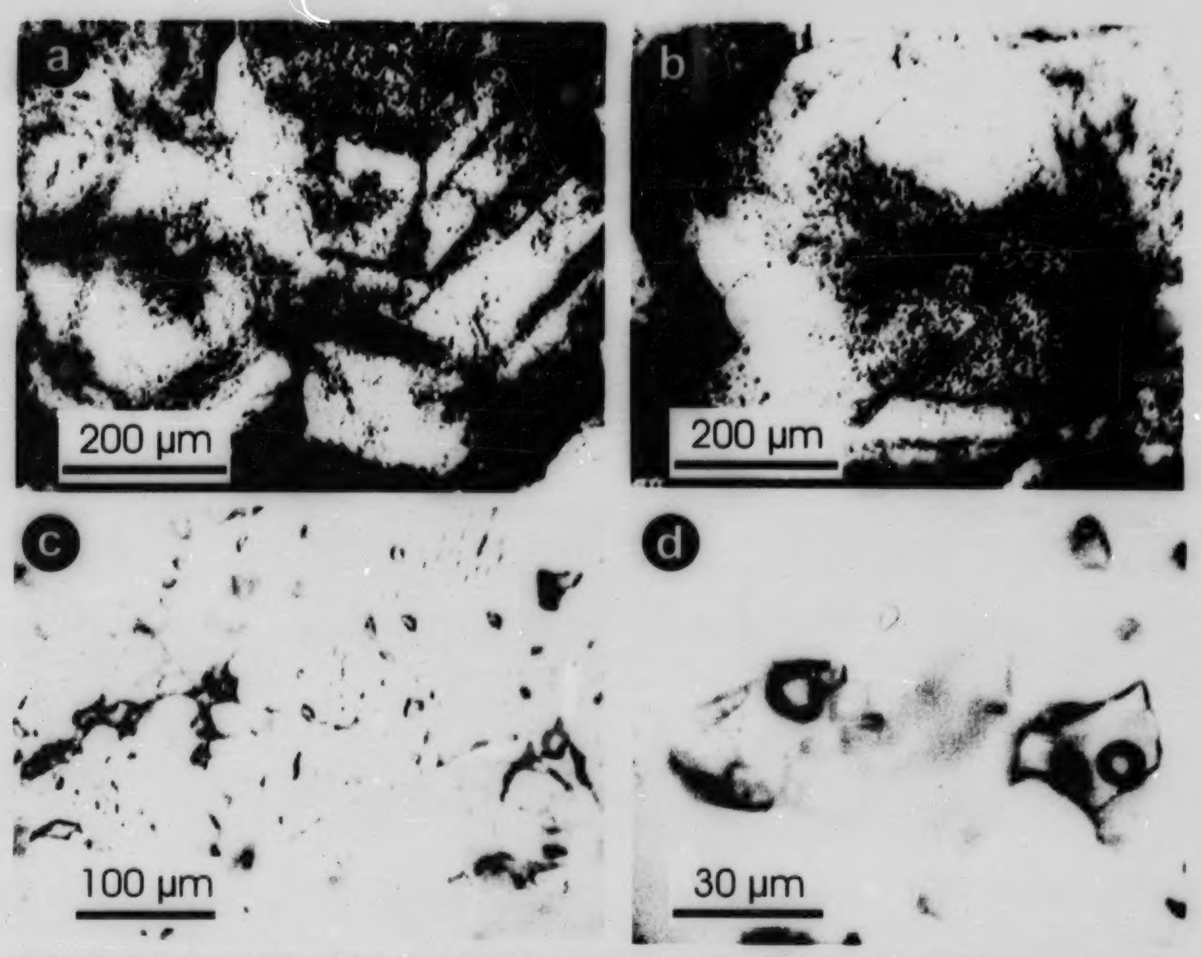

Figure 3. Photomicrographs of quartz-rich material from silica-clay deposit in plane polarized light showing nature and distribution of fluid inclusions. (a, b) Euhedral quartz grains with zonally arranged fluid inclusions outlining growth zones and core areas. The quartz is dark because of the abundance of fluid inclusions. (c) Plane of necked fluid inclusions in quartz with highly variable L:V ratios. Note that the vapor-rich nature of the inclusions is not primary and relates to necking down. (d) Large, aqueous fluid inclusions with similar L:V ratios. Note the accidentally trapped solid phase (S) in the left inclusion.

Homogenization temperatures (Fig. 4) of type 1 inclusions vary from 141° to 218°C; however, for a given fluid inclusion population a range of ≤5°C occurs. The large range indicates that fluids of different temperatures were trapped over time or, conversely, fluids were trapped at both varying pressures and uniform pressures.

Decrepitate Analysis

A sample of quartz used for thermometric study was heated to 450 - 600°C to induce thermal decrepitation of fluid inclusions. This heating results in formation of precipitate mounds which may then be analyzed semi-quantitatively via the electron microprobe (Haynes *et al.*, 1988). In addition, the evacuated inclusions may be examined for solid inclusions with use of the imaging facilities on the electron microprobe.

Examination of evacuated inclusions revealed the following features. (1) An abundance of empty or evacuated cavities were found without any precipitates in the surrounding areas (Fig. 5a). Whereas some of these cavities may represent inclusions that were opened during sample preparation (i.e. sawing and grinding), the abundance of such areas in the sample is unusual and suggests the former presence of very low-salinity fluids. (2) The occurrence of barite and kaolinite (Fig. 5b, c, d) was confirmed by microprobe analysis within evacuated

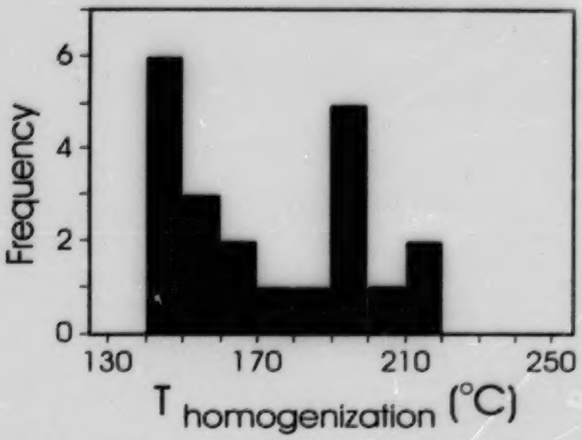

Figure 4. Histogram of homogenization temperatures for aqueous fluid inclusions where similar L:V ratios occur for individual groups or populations of inclusions. Note that the range of temperatures within a population of inclusions is ≤5-10°C.

inclusions, with barite being common. In addition, it was noted that in several cases salt precipitates occurred near the inclusions containing barite (Fig. 5d, e).

The general paucity of precipitate mounds in the quartz sample studied is unusual, certainly compared to what is generally observed in our examination of hypogene quartz from veins and pegmatites that contain inclusions of moderate salinity (e.g. 10-20 wt. % eq. NaCl). In the present cases, two types of mounds were noted: those of equant shape and those of stellate shape (Fig. 5e and f, respectively). Analysis of these mounds, summarized in Figure 6, indicates that they are dominantly of NaCl ± K and KCl ± Na composition, respectively, with minor amounts of Ba consistently detected (Fig. 6). The Ba-rich analysis in Figure 6 corresponds to barite present within the inclusions. The only other cation noted was Ca, present in very minor amounts.

Stable Isotopes

Three samples of quartz and two of kaolinite were analyzed for $\delta^{18}O$ at the isotope laboratory, Department of Geological Sciences, Queen's University. Details of the analytical procedures are found in Kyser *et al.* (1998). The quartz samples are fine-grained, euhedral quartz infilling open space in silica-rich breccia and the kaolinite is a very fine-grained, white powdery material interstitial to silica-rich breccia. The measured $\delta^{18}O$ and δD values (in ‰) are shown in Table 1 along with the calculated $\delta^{18}O_{H2O}$ and δD_{H2O} values for 250°and 300°C, using the appropriate fractionation equations [Zheng (1993) and Sheppard and Gilg (1996), respectively].

Measured $\delta^{18}O$ values for quartz cover a large range for a mineral of apparently a single paragenesis, but the limited mineralogy does impede recognition of what might be a more complicated evolution. In Figure 7 the quartz data are compared to results for vein and pegmatitic quartz from a variety of occurrences in the South Mountain and Musquodoboit batholiths. The quartz samples in this study, albeit limited, appear to cover most of the range for the data set in Figure 7. It should be noted that for the Dunbrack vein Pb-Zn-Cu-Ag occurrence, the high $\delta^{18}O$ values compared to the rest of the data set relate to the lower temperature of quartz deposition compared to the other occurrences, combined with the fact that at lower temperatures ^{18}O is preferentially concentrated in quartz over water.

The two kaolinite $\delta^{18}O$ levels are essentially similar at +14‰ and compare to $\delta^{18}O$ levels of +13.8 and +17.1‰ for late-stage kaolinite at the East Kemptville Sn-base metal deposit (Kontak, 1994) and Dunbrack occurrence (Kontak *et al.*, 1999), respectively. The δD levels for the two kaolinite samples are also similar at -61 and -60‰, which compare to a level of -103‰ for kaolinite from Dunbrack, the only other kaolinite sample for which such data are available.

The levels of $\delta^{18}O_{H2O}$ and δD_{H2O} in equilibrium with the quartz and kaolinite have been calculated for 250° and 300°C (Table 1), the former being constrained by fluid inclusion data and the later being the temperature at which kaolinite converts to pyrophyllite. The quartz data indicate $\delta^{18}O_{H2O}$ levels of +0.9 to +7.6‰ and contrast with the +10.7 to +12.8‰ obtained for kaolinite. These levels in part overlap the range of $\delta^{18}O_{H2O}$ values typical of magmatic water derived from metaluminous to peraluminous granites (Sheppard, 1986), but levels below ca. 5‰ indicate another fluid reservoir. The δD_{H2O} levels of -45‰ are in the range for magmatic waters (Sheppard, 1986). It is important to note here that the presence of kaolinite in evacuated inclusions within quartz (Fig. 5c) indicates that at least some kaolinite formed at similar temperatures as quartz and is, therefore, also constrained by the fluid inclusion homogenization temperatures. However, it is possible that some kaolinite also formed at lower temperatures.

Discussion

The results of fluid inclusion and stable isotope measurements permit some constraints to be made on the nature of the fluids responsible for mineralization at Flintstone Rock. In addition, the data are discussed in

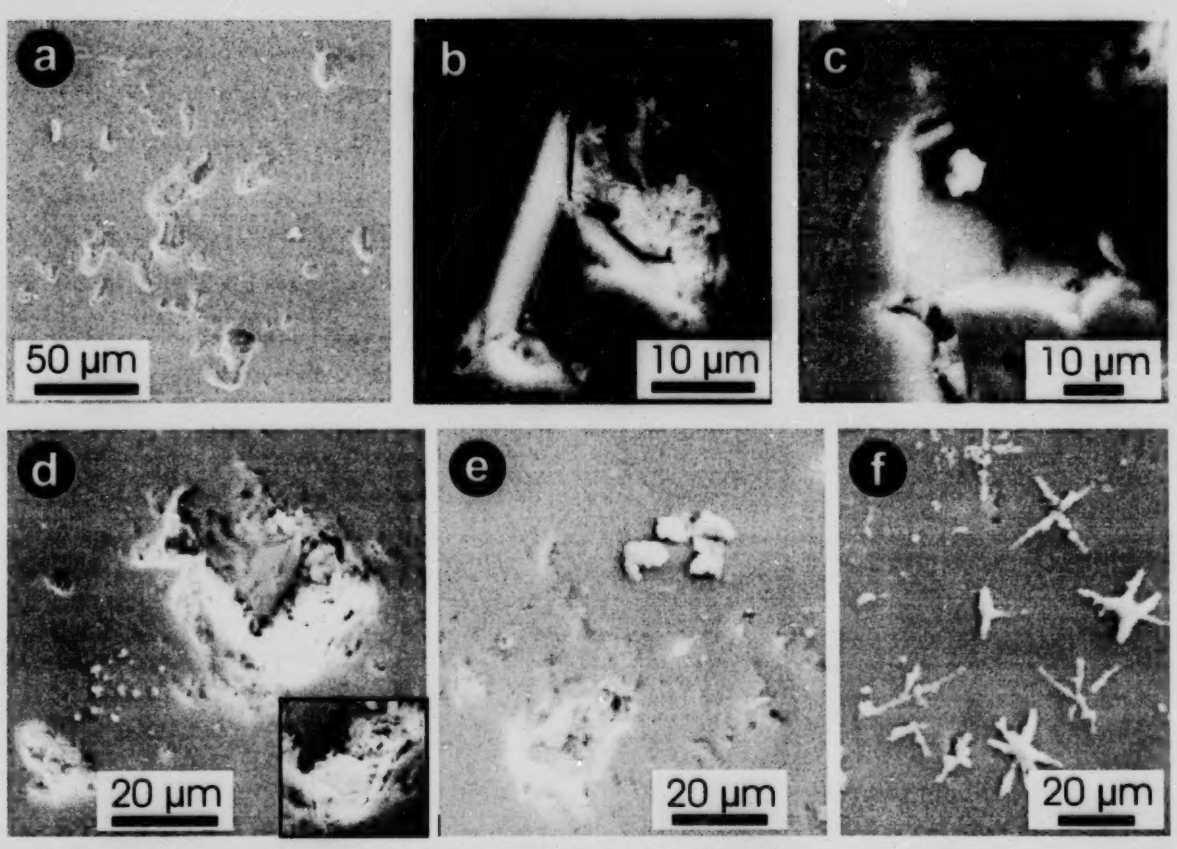

Figure 5. Combined back scattered and secondary electron images of thermally decrepitated sample of quartz showing the presence of evacuated inclusions and salt precipitates or mounds formed from decrepitation of fluid inclusions. (a) Multiple opened inclusions typical of many areas of quartz. Note the absence of any precipitate mounds in the area of the opened inclusions. (b) Opened inclusion with barite coating the bottom of the cavity. (c) Opened inclusion with small kaolinite grain resting in bottom of the negative-shaped cavity. (d) Opened inclusions with NaCl mounds present between the two larger cavities. The largest cavity has a euhedral barite crystal growing on its bottom wall (see inset). (e) Equant-shaped mounds of NaCl composition near an evacuated inclusion which contains small grains of barite coating the walls of the inclusion. (f) Area of quartz with abundant stellate-shaped mounds of KCl composition.

light of other mineral occurrences in the surrounding area, such as at Little Tobeatic Lake and East Kemptville, in order to make some comments on the implications of the results to the regional metallogenetic evolution.

Nature of Mineralizing Fluids

Fluid inclusion studies indicate that infiltration of a dilute (ca. 0 wt. % eq. NaCl) fluid with Na, K and Ba in solution was responsible for the mineralization. These solutes, albeit in low concentrations, are nevertheless consistent with the apparently widespread and pervasive dissolution of the feldspar component of the Davis Lake Pluton which would have liberated Na, K and Ba. However, the low salinity of the fluid is contrary to the nature of magmatic fluids (Roedder, 1984) and given the absence of any petrographic evidence of fluid unmixing or boiling, implicates another fluid type as being involved in the mineralization. The most likely source of a dilute fluid is surficial water, also known as meteoric water, which is commonly reported in high-level or epithermal environments (e.g. Bodnar *et al.*, 1985). If the fluid inclusion data for mineralization at Little Tobeatic Lake (Corey and Graves, 1996) are combined with the present data set, then a continuum is seen from high temperature fluids of 400°C and ca. 20-25 wt. % eq. NaCl to ca. 200°C and 0 wt. % eq. NaCl, as summarized in Figure 8. Also shown in the Figure 8 is the fluid responsible for greisen mineralization at the nearby East Kemptville tin deposit, which is similar to the saline component of the fluid in the Tobeatic Fault Zone. The presence of barite, adularia and Zn-Fe- Pb-Cu sulphides in the veins at Little Tobeatic Lake is

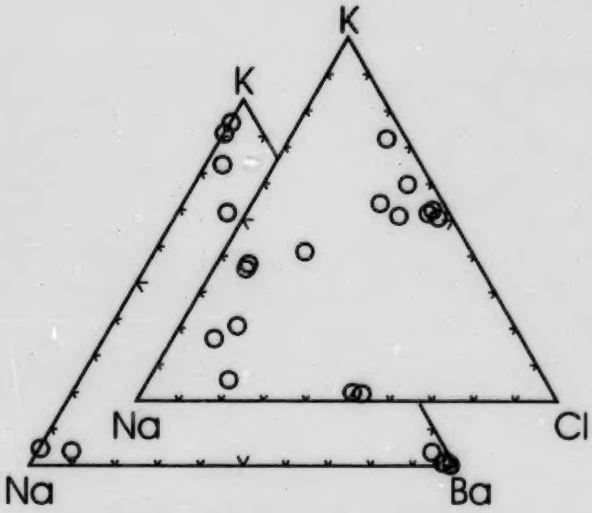

Figure 6. Ternary plot of Na-K-Ca for decrepitate mounds analyzed on the electron microprobe.

consistent with a magmatic component in the fluid and, thus, explains the higher temperatures and salinities for vein material. The presence of barite in the fluid inclusions at Flintstone Rock also provides a geochemical link between the two areas in terms of their genesis.

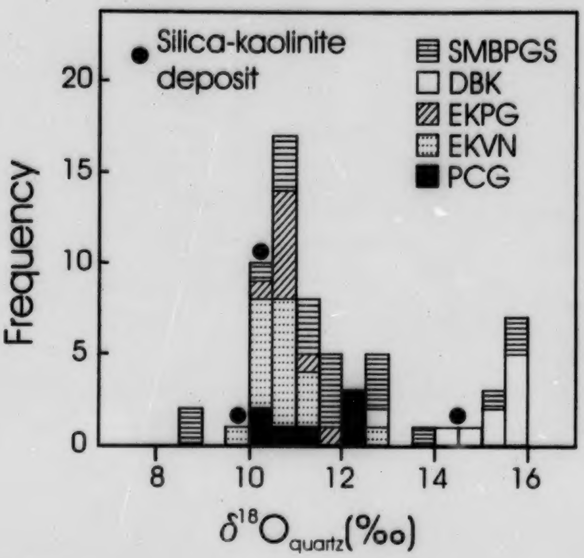

Figure 7. Summary of $\delta^{18}O_{quartz}$ levels for quartz from the silica-clay deposit compared to $\delta^{18}O_{quartz}$ levels for a variety of 370 Ma granite-related occurrences in the Meguma Terrane: SMBPGS-pegmatitic quartz from various localities in the South Mountain Batholith (e.g. Keddy's, Moreley's, Reeves, Walker; Kontak *et al.*, 1991), DBK-quartz vein material from Dunbrack Pb-Zn-Cu-Ag occurrence (Kontak *et al.*, 1999), EKPG-pegmatitic quartz from East Kemptville (Kontak *et al.*, 2001a), EKVN-vein quartz from East Kemptville (Kontak, 1994), PCG-pegmatitic quartz from Peggys Cove (Kontak *et al.*, 2001b). Note that the reason for the relative enrichment of Dunbrack vein quartz in $\delta^{18}O$ is that they formed at relatively lower temperatures than the other occurrences sampled, combined with the fractionation for $\delta^{18}O$ quartz-H_2O which favors enrichment of ^{18}O in quartz at low temperatures.

Stable isotope data, although restricted to three quartz and two kaolinite samples, permit some important constraints. First, as noted above, the $\delta^{18}O$ data for quartz indicate two contrasting values which translate into quite different $\delta^{18}O_{H2O}$ values. These data can be interpreted in at least three different ways, as indicated by the models summarized in Figure 9. A two-fluid model would require fluids having $\delta^{18}O_{H2O}$ values of ca. +7 and +3‰ to have been involved in mineralization, assuming quartz deposition at ca. 300°C. In the one-fluid model, quartz would have to be deposited at temperatures of ca. 300°C and ca. 150°C from a single fluid with a $\delta^{18}O_{H2O}$ value of +7‰. And finally, a two-fluid mixing model would have a primary fluid with a $\delta^{18}O_{H2O}$ value of +7‰ mixing with a fluid of much lower $\delta^{18}O_{H2O}$ value (e.g. ≤21) to generate a second fluid with an intermediate $\delta^{18}O_{H2O}$ value. The following constraints indicate that the two-fluid mixing model (#3 in Fig. 8) is the most likely. (1) Fluid inclusion data for the Flintstone Rock and Little Tobeatic areas indicate that mixing of two fluids occurred, these likely being of magmatic and meteoric origin. (2) Fluid inclusion thermometric data indicate that the quartz samples with the relatively lower $\delta^{18}O$ values were not deposited at ca. 150°C, as required in the one-fluid model (#2 in Fig. 8), but instead at much higher temperatures. (3) Quartz with the $\delta^{18}O$ level of +14‰ has a $\delta^{18}O_{H2O}$ level of +7‰ at 300°C, which is similar to the magmatic signature of $\delta^{18}O_{H2O}$ for the South Mountain Batholith at this temperature. Thus, quartz with a +14‰ signature equates to quartz with $\delta^{18}O$ levels of +10‰ from veins and pegmatites in the SMB (Fig. 7) that were deposited at ca. 500°C and suggests that this is a magmatic signature. Whereas points 1 and 2 eliminate the single-fluid model, the two-fluid model is ruled out as being unlikely since it cannot explain the mixing of two fluids, one with a magmatic signature and the other with a meteoric signature, based on fluid inclusions.

The $\delta^{18}O_{H2O}$ levels calculated using kaolinite are +8.6 to +10.6 ‰ for formation at 250-300°C (Table 1). These levels are higher than $\delta^{18}O_{H2O}$ levels calculated using quartz and suggest isotopic disequilibrium. Another way of examining this is to calculate the $\delta^{18}O$ levels of kaolinite in equilibrium with the waters that

Table 1. Isotopic data for quartz and kaolinite samples from Yarmouth silica-kaolinite deposit.

Sample	Mineral	$\delta^{18}O$ (‰)	$\delta^{18}O$ H_2O (300°C) (‰)	$\delta^{18}O$ H_2O (250°C) (‰)	δD (‰)	δD H_2O (300°C) (‰)	δD H_2O (250°C) (‰)
FR-99-01	quartz	9.8	2.9	0.9			
DK-99-A	quartz	14.5	7.6	5.6			
59	quartz	10.4	3.5	1.5			
99-39-1A	kaolinite	14	10.2	8.6	-61	-46.6	-45.2
99-39-1B	kaolinite	14.4	10.6	9.0	-60	-45.6	-44.2

deposited the quartz using the appropriate fractionation factors. When this is done, using a $\delta^{18}O_{quartz}$ level of +14.5‰, it is determined that the kaolinite $\delta^{18}O$ levels should be ca. +10.5 to +11.3‰ for deposition at 200-300°C. These levels compare to the ca. +14‰ $\delta^{18}O$ measured for kaolinite and again suggest that the two minerals are not in isotopic equilibrium. One possible interpretation of these data is that kaolinite may have exchanged at a lower temperature with another fluid after its initial formation, resulting in an increase in its $\delta^{18}O$ level, as would happen if exchange with low temperature surficial water occurred in a supergene environment. A similar scenario has been reported for kaolinite in Hercynian granites in Britanny, France (Boulvais *et al.*, 2000). At this locality and also in Cornwall, England (Psyrillos *et al.*, 1998), upgrading of the granite-hosted kaolinite mineralization occurred during interaction with supergene fluids, with consequent generation of distinct morphologies for the different generations of kaolinite. Detailed mineralogical investigation is planned to evaluate this possible scenario. The similar $\delta^{18}O$ level for kaolinite at Flintstone Rock and East Kemptville suggests a similar origin for kaolin formation at the two sites.

The δD data for the two kaolinite samples indicate δD_{H2O} levels of ca. -45‰, which is within the range for magmatic fluids (Sheppard, 1986). However, the δD data are also consistent with a meteoric water influence, given that the moderate latitudes of Nova Scotia during the Late Devonian-Carboniferous equate to a similar range of δD levels.

In summary, the mineralizing fluid at Flintstone Rock appears to represent an end member of two fluids of magmatic and meteoric origin that mixed within the Tobeatic Fault Zone. Whereas the meteoric-dominant fluid gave rise to extensive silica-kaolinite mineralization, the magmatic component also contributed to deposition of base metals and precious metals in the Little Tobeatic Lake area.

Nature of the Mineralizing Environment at Flintstone Rock

The nature of the mineralization at Flintstone Rock indicates that fluids penetrated a fault zone, and that internally conditions favored repeated brecciation of the vein fill. The structural fabrics of wallrock and fragments also indicate that initial ductile deformation occurred, subsequently followed by brittle conditions. The magnitude of this structure (i.e. strike length) suggests that it is part of a regional rather than localized event and, as discussed by Horne *et al.* (1992), this structure, the Tobeatic Fault Zone (Fig. 1), was active during emplacement of the South Mountain Batholith. The many similarities between the setting of the Flintstone Rock silica-clay deposit and the greisen-hosted Sn-base metal deposit at East Kemptville suggest that the two share a common origin, but with the nature of the fluids (i.e. magmatic- versus meteoric-dominant) relating to the differences in type of mineralization.

In Figure 10, a pressure-temperature plot, the salient aspects of the mineralization are shown. The field denoting the conditions of mineralization based on fluid inclusion data is shown along with extrapolation to higher P and T using the iso-T_h lines. However, in order to better constrain the P-T conditions, an estimate of either temperature or pressure is required. Assuming that mineralization occurred shortly after emplacement and crystallization of the South Mountain Batholith, as suggested from geological arguments, and the fact that the only known source of magmatic fluid in the area relates to 370 Ma granitic magmatism, then the maximum pressure during formation is indicated by the contact aureole of the South Mountain Batholith at 3.2-3.5 kbar. However, fluid inclusion isochores for the fluids indicate a maximum P of ca. 1.2 to 2.7 kbar at 300°C, the upper limit of kaolinite stability. This pressure differential indicates that the confining pressure was somewhere between lithostatic and hydrostatic,

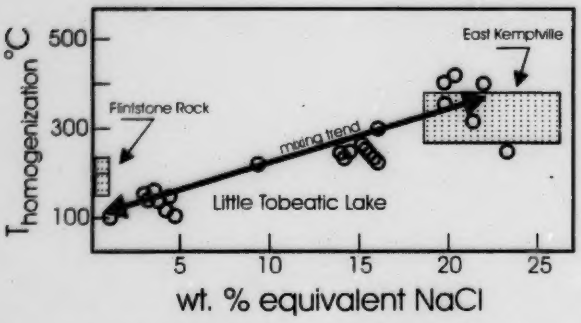

Figure 8. Plot of fluid inclusion homogenization temperature versus salinity for inclusions from the Flintstone Rock silica-clay deposit, mineralization at Little Tobeatic Lake (Corey and Graves, 1996), and East Kemptville (data of Kontak). Note that the salinities at East Kemptville extend to ca. 42 wt. % eq. NaCl.

which can be reconciled with the fact that large volumes of low-salinity fluid must have infiltrated the system via an open and connected network of fractures. Thus, the depth of mineralization may indeed have been ca. 10 km. Assuming this setting to be correct, the ambient temperatures, for a typical continental geotherm of 25°C/km, would have been 250°C. Given that this temperature is close to that inferred for mineralization, it indicates that descending fluids were heated by the adjacent granitic intrusion.

Implications for Local and Regional Mineralization

Integration of the results of the present study with the documentation of abundant silica ± clay occurrences along the strike length of the Tobeatic Fault Zone (e.g. Rushmere Lake, Little Tobeatic Lake, geophysical work of Black Bull) indicates high potential for lateral continuation of the Flintstone Rock deposit to the northeast and southwest. However, the potential for kaolinite would be confined to that part of the structure that lies within the Davis Lake Pluton, since the kaolinite originates from alteration of primary feldspar minerals.

The presence of a major, northeast-trending structure subparallel to the Tobeatic Fault Zone and within the DLP, this being the East Kemptville-East Dalhousie Fault Zone, also offers potential for similar occurrences. In fact, the presence of extensive hematite alteration, and U (e.g. Millet Brook) and Mn (e.g. New Ross area) proximal to fault and breccia zones along the middle and eastern extent of this fault (Horne *et al.*, 1992 and personal communication, 2001; O'Reilly, 1992) indicates infiltration of fluids. Recent fluid inclusion studies on some of this material have shown that mineralizing fluids were of variable salinity, including fluids of ≤2 wt. % eq. NaCl (Carruzzo *et al.*, 2001), in addition to magmatic fluids. Thus, a similar setting and origin of fluids is apparent along the two fault structures, which indicates similar potential of mineralization.

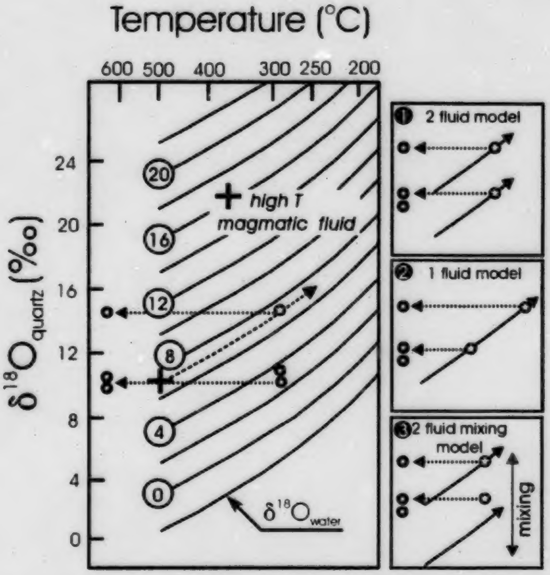

Figure 9. Plot of Temperature versus $\delta^{18}O_{quartz}$ for silica-clay deposit with calculated $\delta^{18}O_{water}$ isopleths (circled numbers) for a fluid in equilibrium with quartz of known $\delta^{18}O$ at a specific temperature. This diagram shows that based on the three quartz samples analyzed, three interpretations are possible, as shown in the boxes labeled 1, 2 and 3. In these boxes the arrows represent fluid evolution lines and the symbols the points where quartz is precipitated with a corresponding $\delta^{18}O_{quartz}$ value indicated on the side. Models are: (1) Two distinct fluids with $\delta^{18}O$ values of +3 to +7 ‰ assuming that quartz was deposited at similar temperatures of ca. 250-300°C. (2) A single fluid with initial $\delta^{18}O$ values of ca. +3 ‰ with quartz deposition at ca. 250-300°C and subsequently at 200-150°C (3) Two fluids with $\delta^{18}O$ values of 0 and +7 ‰ with some quartz deposited from the fluid of +7 ‰ and the rest from a fluid that represents mixing of the two such that its composition is +3 ‰, which would indicate roughly equal volumes of the two fluids mixed. Also note in the diagram that the cross (+) denotes a fluid of magmatic origin that would have deposited many of the pegmatitic and vein quartz occurrences in the South Mountain Batholith with $\delta^{18}O$ levels of +10 to +11 ‰, as summarized in Figure 7. This fluid is of similar isotopic composition to one of the fluids mentioned in the above discussion and in the text.

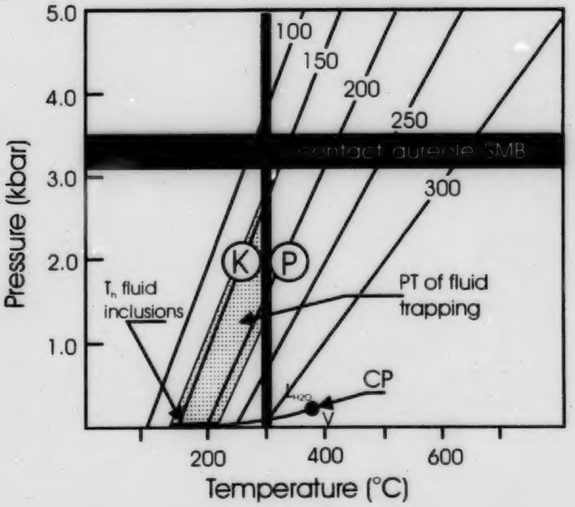

Figure 10. Pressure-Temperature plot showing the following: (1) iso-T_h lines (i.e. homogenization temperatures for fluid of uniform composition) for fluid with salinity of 0 wt. % NaCl (from Bodnar and Vityk, 1994); (2) inferred pressure of contact aureole for the South Mountain Batholith (Raeside and Mahoney, 1996); (3) stability of kaolinite (K) and pyrophyllite (P); (4) range of fluid inclusion homogenization temperatures obtained in this study for quartz-hosted inclusions from the silica-clay deposit. The shaded area extending from the dark line delimits the inferred range of conditions for formation of the silica-clay deposit. (5) L-V curve for water, with critical point (CP) indicated.

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Geological Setting and Fluid Inclusion Study of Celestite Mineralization, Beckwith (NTS 11E/13), Nova Scotia

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Introduction

Celestite and minor galena occur as isolated pods in an unconsolidated clay unit of Early Carboniferous age in the Cumberland Basin of southern Nova Scotia (Fig. 1). Felderhof (1978) suggested that the Beckwith occurrence resulted from a combination of fault-related and vein mineralization, but exploration in the late 1980s revealed that this deposit is not a vein, but instead is spatially related to nearby faulting (Felderhof, 1986). In this paper we outline the geological setting of this unusual celestite-galena occurrence, review previous work, and present the first results of fluid inclusion studies carried out on celestite samples. Although not currently economic, the deposit provides a unique opportunity to examine the mechanism responsible for this unusual type of mineral occurrence and, as such, may have implications for other, larger and more promising celestite deposits in the province (e.g. Lake Enon) and elsewhere.

General Geology

The Beckwith deposit lies adjacent to a fault between Upper Carboniferous terrestrial sandstones (Cumberland and Pictou groups) and Lower Carboniferous marine evaporites (Windsor Group) in the Cumberland Basin, northern Nova Scotia (Fig. 1). The basin is a segment of the Maritimes Basin, a large upper Paleozoic basin in eastern Canada (Fig. 1a), which hosts significant resources of fossil fuels, precious metals, base metals and industrial minerals. The Permo-Carboniferous system of eastern Canada comprises a post-Acadian molassic suite of coarse- and fine-grained terrestrial and volcanic rocks, as well as shallow marine clastic, carbonate and evaporitic rocks. It underlies an irregular area of lowland extending from the Bay of Fundy through the Gulf of St. Lawrence to offshore Newfoundland. The onshore distribution extends from eastern Maine to Newfoundland and southern mainland Nova Scotia to Quebec (Fig. 1).

Cumberland Basin Geology

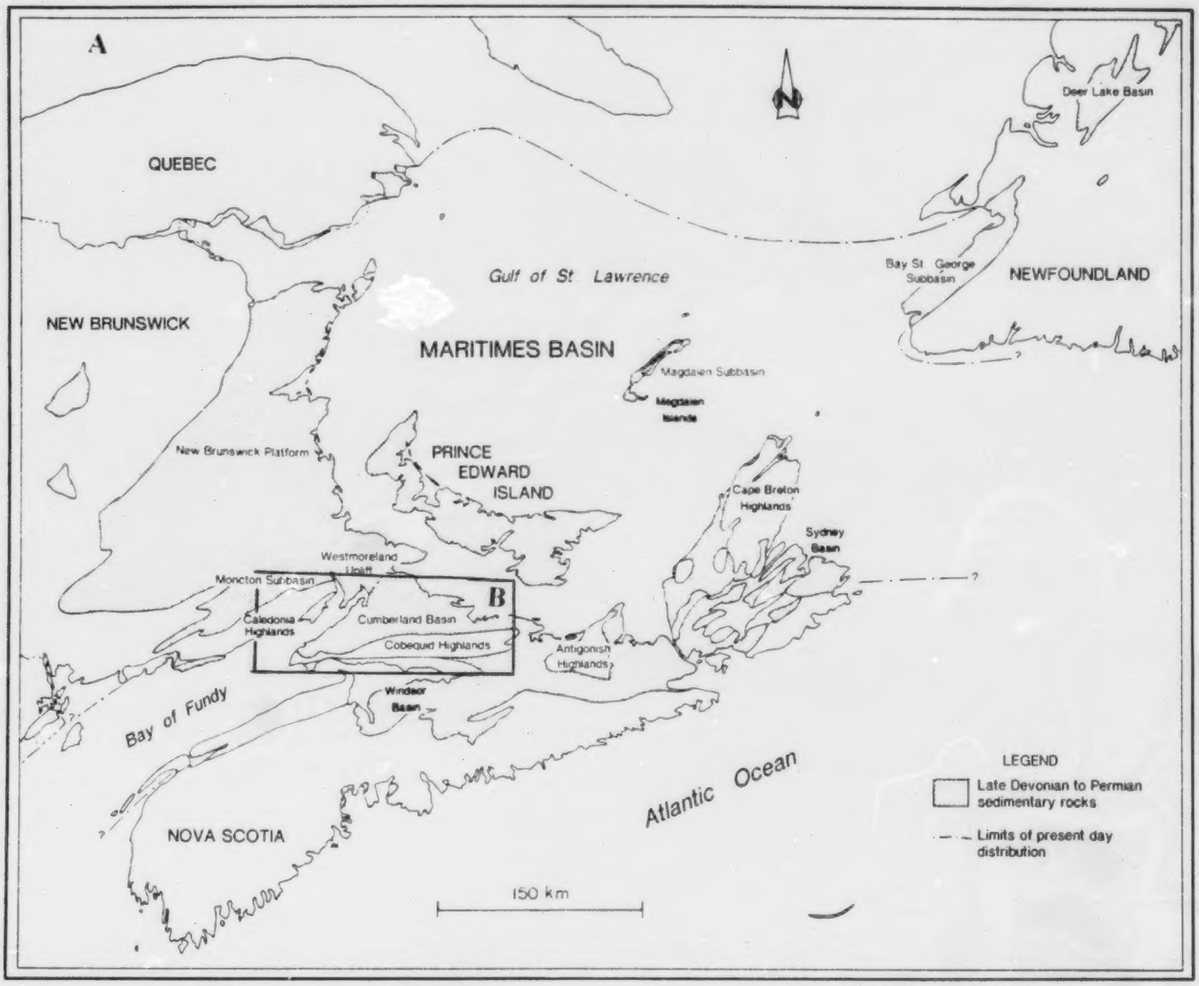
The Cumberland Basin is an east-west depocentre which contains a succession of sedimentary strata in excess of 7 km thick (Fig. 1b). The internal structure of the basin is a broad, east-west synclinorium enclosing two parallel, diapiric anticlinal structures. The basin has a Devono-Carboniferous redbed and volcanic sequence referred to as the Fountain Lake Group at the base, succeeded by fluvial/lacustrine red and grey shale and sandstone of the Horton Group.The Horton Group is overlain by marine clastics, evaporites and carbonates of the Windsor Group. The unit of most interest to this paper is the thick (300 m) anhydrite/gypsum beds of the Pugwash Mine and Lime Kiln Brook formations and their laterally equivalent halites (Pugwash Formation).

Overlying the Windsor Group are strata of the Mabou Group, which are divided into two formations. The lower unit is red-brown mudstone, siltstone and sandstone with rare, thin, polymictic conglomerate interbeds (nonmarine). The upper unit is greenish-grey sandstone with minor calcareous conglomerate, mudstone and siltstone.

The Mabou Group is overlain by the Cumberland Group, which consists of red and grey boulder to pebble polymictic conglomerate, grey sandstone, grey to reddish-brown mudstone, siltstone, coal seams from 0.01 m to 3.5 m thick, and thin, bituminous black limestone and shale. The Cumberland Group is overlain by the redbed-dominated rocks of the Pictou Group, in which varying proportions of sandstone and mudstone occur.

Location and Previous Work

The Beckwith celestite occurrence is located adjacent to Dickson Brook (Hayes and Bell, 1938) ca. 1.3 km south of Beckwith and approximately 6 km southwest of Highway 6 at Port Howe, Cumberland County, Nova Scotia (Fig. 2). The area has low relief with elevations ranging from 25 to 40 m above sea level and outcrop is rare. The celestite-galena occurs near a fault boundary where Windsor Group evaporites are juxtaposed next to the red and grey sandstone and shale of the upper part of the Cumberland Group (Fig. 2).


A
N
QUEBEC
Deer Lake Basin
Gulf of St Lawrence
Bay St George Subbasin
NEWFOUNDLAND
NEW BRUNSWICK
MARITIMES BASIN
Magdalen Subbasin
Magdalen Islands
New Brunswick Platform
PRINCE EDWARD ISLAND
Cape Breton Highlands
Sydney Basin
Westmoreland Uplift
Moncton Subbasin
B
Caledonia Highlands
Cumberland Basin
Cobequid Highlands
Antigonish Highlands
Windsor Basin
Bay of Fundy
Atlantic Ocean
NOVA SCOTIA
150 km
LEGEND
Late Devonian to Permian sedimentary rocks
Limits of present day distribution

The first reported work on the occurrence dates to 1911 when H. G. Elliot discovered what he thought to be barite and a 9 m shaft was sunk in the bank of the brook. Little work took place on the property until 1941 when Springer Sturgeon Gold Mines Limited carried out some trenching in order to expose the bedrock; however, only one trench encountered bedrock. The next work was carried out by F.M.C. Limited in 1969 and 1970. This company exposed 5 m of celestite in a trench and followed this up with geophysics, rotary drilling (over 1500 m in 42 holes) and diamond-drilling (over 1000 m in 36 holes). Drilling indicated that the "vein" was discontinuous and occurred within or near a fault gouge.

The latest work on the occurrence, carried out in 1985-1986 by ACA Howe International for Timminco Ltd., consisted of trenching, mapping, bulk sampling and both rotary- and diamond-drilling. There were nine diamond-drill holes totaling 300 m length and 27 percussion holes that totaled 110 m. The trenching was extensive and a pit measuring approximately 60 m by 45 m was excavated to a depth of greater than 10 m (Fig. 3).

Deposit Geology

The host rocks of the deposit area have been variably described by previous workers as faulted sandstone and mudrocks. The excavation in 1986 revealed that red and grey sandstone, siltstone and pebble conglomerate occupy the east side of the pit, whereas gypsum was encountered in drillholes to the west and north sides of the pit (Fig. 3a). The sandstone and clastic sedimentary rocks to the east are part of the Cumberland Group and the gypsum is part of the Windsor Group. Celestite can be found associated with brecciated sandstone along the eastern side of the deposit, but it is more commonly found in poorly consolidated grey and red clay units (Fig. 3c).

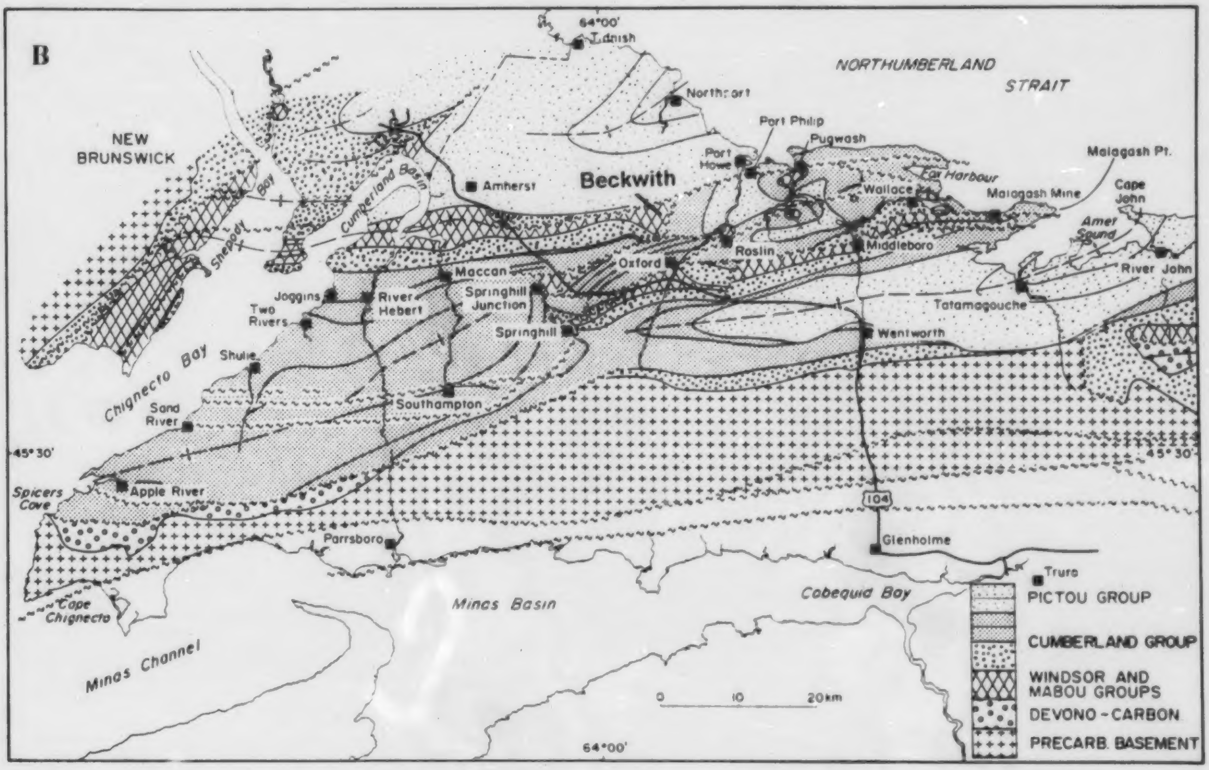

B
64°00'
Tidnish
NORTHUMBERLAND STRAIT
Northport
Port Philip
Pugwash
Port Howe
NEW BRUNSWICK
Shepody Bay
Cumberland Basin
Amherst
Beckwith
Wallace
Car Harbour
Malagash Pt.
Malagash Mine
Cape John
Amet Sound
River John
Roslin
Middleboro
Oxford
Maccan
Springhill Junction
Joggins
River Hebert
Two Rivers
Springhill
Tatamagouche
Wentworth
Shulie
Chignecto Bay
Sand River
Southampton
45°30'
45°30'
Spicers Cove
Apple River
104
Parrsboro
Glenholme
Truro
Cobequid Bay
Minas Basin
Cape Chignecto
Minas Channel
0
10
20km
64°00'
PICTOU GROUP
CUMBERLAND GROUP
WINDSOR AND MABOU GROUPS
DEVONO - CARBON
PRECARB. BASEMENT

Figure 1. (a; previous page) Location map of the Maritimes Basin in eastern Canada with a location of Figure 1b. (b) Generalized geology map of the Cumberland Basin with the location of the Beckwith celestite occurrence (from Ryan and Boehner, 1994).

Contacts between the Upper Carboniferous clastic strata and the Windsor Group rocks can only be rationalized as faults. Ryan *et al.* (1990) indicate that there are faults both north and south of the occurrence and, given the nature of other Windsor Group outcrops in the Cumberland Basin, it is reasonable to assume that the evaporites are part of a diapiric structure (Fig. 4). In fact, just west of the Beckwith area there is a significant negative Bouguer gravity anomaly interpreted to reflect the presence of salt at depth (Boehner, 1986).

Celestite Mineralization

The long-standing theory of the occurrence of celestite on the property was that it was a fault-related vein deposit. The exploration and pit development undertaken in the 1980s by ACA Howe International suggest that this is erroneous (Felderhof, 1986). Drilling and excavation revealed that the celestite occurs as isolated pods within poorly consolidated red and grey clay (Figs. 3a, b). These pods are up to 8 m in length, 4 m in width, and up to 3 m in thickness (e.g. Fig. 3b). This mode of occurrence greatly reduces the economic viability of the property, but it is of scientific significance because of the unusual morphology of the celestite.

The large masses or pods of celestite are generally surrounded by grey clay, although red clay is common proximal to the pods (Fig. 3c, d). Minor amounts of celestite have been observed in brecciated red sandstone on the east side of the pit. The celestite can also occur as pebble- to sand-sized crystals which appear to be displacing the clay host. The smaller celestite crystals are almost always hosted in the grey clay. It is unclear as to whether the grey coloration of the clay is related to alteration during mineralization or if the mineralization preferentially occurred within the grey (reducing) clay zones.

Celestite at Beckwith ranges in colour from translucent to light cream and celestial blue. The individual crystal blades can be up to 2.5 cm in length. Ore in the large pods exhibits numerous open vugs between the crystals, which are usually filled with the

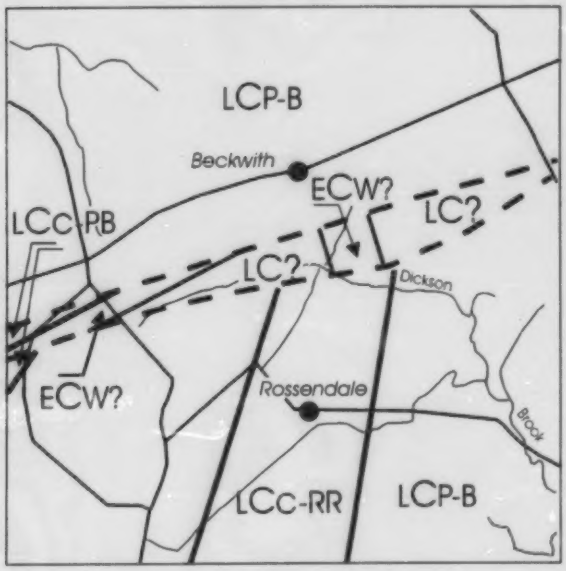


Figure 2. Geological map of the area around the Beckwith celestite occurrence. Abbreviations are as follows: ECW is Windsor Group, LC and LCC-RR are Cumberland Group strata, and LCP-B refers to Pictou Group strata.

surrounding clay. In a few areas in the pit minor amounts of galena were observed. Galena occurs as small (less than 5 mm) cubic crystals growing on the celestite blades of the coarse ore. Barite has also been reported in minor amounts within the more massive celestite pods. Felderhof (1978) reported an average $BaSO_4$ content of 2.5 wt. % within 87 wt. % celestite ($SrSO_4$) ore.

The size of the celestite resource at Beckwith remains unclear. Exploration on the property was predicated with the assumption that the occurrence was a mineralized vein, whereas it is now clear this is not the case. Felderhof (1986) suggested that the resource defined by drilling and excavation was only 1150 tonnes of ore-grade celestite.

A palynological sample taken from the pit was determined to be of Viséan age (Ryan and Boehner, 1994) suggesting, therefore, that the clays are either Windsor Group sediments or derived from them. Red and grey siltstone and silty shale are common within the Windsor Group; however, the presence of thick clay or claystone has not been reported. The lack of visible bedding, unconsolidated nature of the host clays of the Beckwith property, and the fine grain size of the unit are all atypical of Windsor Group clastic strata. Thin clays are common in the evaporites of the Windsor Group and karst features are ubiquitous on the top of the evaporites where they are exposed in the Cumberland Basin. If evaporites are dissolved in the near-surface environment, the end result is an accumulation of insoluble residues after dissolution. In this case, the residuum would be derived from the thin clays interlaminated with salt and gypsum of the Windsor Group evaporite sequence. These clays would be expected to contain spores of Windsor age.

Fluid Inclusion Studies

Samples of coarse celestite from mounds in the excavated trench were crushed, and hand-picked celestite crystals were mounted on glass slides for petrographic observation. The celestite is inundated with inclusions; thus, several chips were made into doubly polished fluid inclusion sections of ca. 150 µm thickness for subsequent petrographic and thermometric study. Results of these studies are summarized below.

Thermometric measurements of the relevant freezing and heating changes of inclusions were made with a U.S. Geological Survey gas flow heating-freezing stage (FLUID INC.) at the Nova Scotia Department of Natural Resources [see Kontak (1998) for details]. The equipment was initially calibrated and is routinely checked with synthetic fluid inclusions. Accuracy for the equipment is estimated at ± 0.2°C for low temperature runs and ±1.0°C for high temperature runs, whereas precision determined from replicate runs is ± 0.2°C or better. In addition, a single celestite chip inundated with fluid inclusions was rapidly heated on the fluid inclusion stage in order to induce thermal decrepitation of the inclusions, which causes formation of precipitate mounds. These mounds were subsequently imaged and analyzed with the electron microprobe at Dalhousie University in order to determine the chemistry of the solute component of the inclusions.

Fluid Inclusion Petrography

Fluid inclusions in celestite occur: (1) decorating growth faces (Fig. 5a, b), (2) along healed fracture planes (Fig. 5f) and (3) as random clusters within the host mineral (Fig. 5c). Type 1 are considered primary, whereas type 2 and 3 are possibly pseudosecondary and primary/secondary, respectively, following criteria of Goldstein and Reynolds (1994). The size, shape and composition (i.e. L:V ratio) of the inclusions vary considerably suggesting, therefore, post-entrapment modification of the inclusions. There is no correlation of these features with the types 1, 2 or 3 mentioned above. Hence, the description of the inclusions below applies to all types.

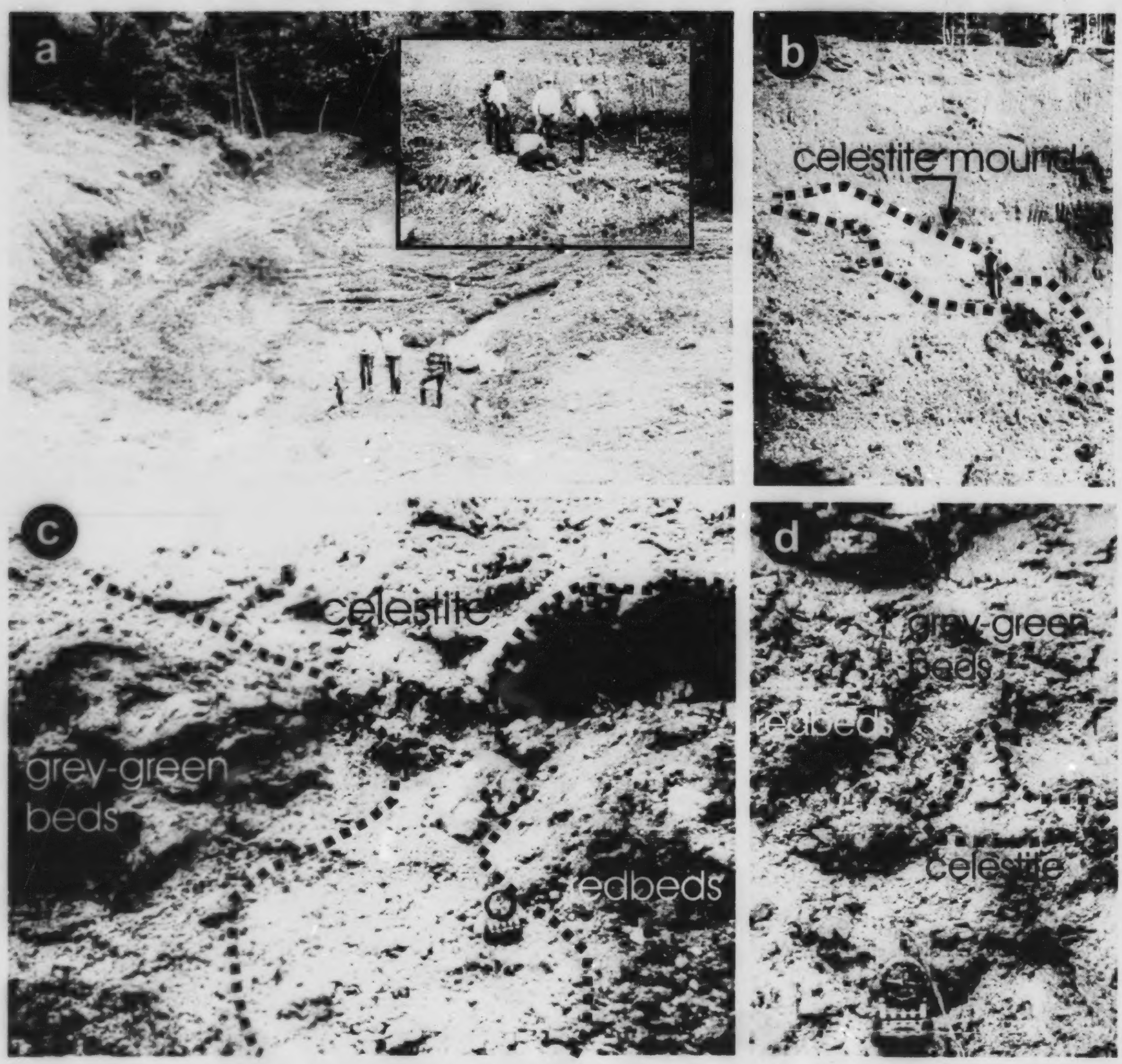


Figure 3. Photographs of the open pit at Beckwith showing the nature of the host rocks and the mineralization. (a) View of open pit looking southeast. People are standing on pod of celestite mineralization, which is enlarged in the inset photo. (b) View of another celestite pod. Person standing for scale. (c) Celestite mineralization in red sediments with grey-green halo around the mineralization. (d) Close-up of celestite mineralization and host rocks.

Inclusions are up to 100-150 μm long, with most ≤10-20 μm (Fig. 5c, d, g). The larger inclusions tend to be elongate or acicular with tapered ends, and have regular to highly irregular outlines (e.g. Fig. 5d, h). Smaller inclusions vary from regular to equant (Fig. 5g), in some cases with negative crystal form, to very irregular; regular-shaped inclusions are dominant. The presence of healed fracture planes decorated with abundant, equant-shaped inclusions indicates necking down was common (Roedder, 1984). The L:V ratio of inclusions is highly variable, such that there is a complete gradation from L-rich to V-rich inclusions (compare fluid inclusions in Fig. 5c), and this is attributed to necking, which is extensive within the celestite (Fig. 5e, h). However, planes of regular to equant inclusions with monophase L-rich inclusions occur, and less commonly planes with uniform L:V ratios. Rare occurrences of unidentified trapped solid phases were noted. Fluid inclusions were examined in ultraviolet (UV) light for the presence of liquid

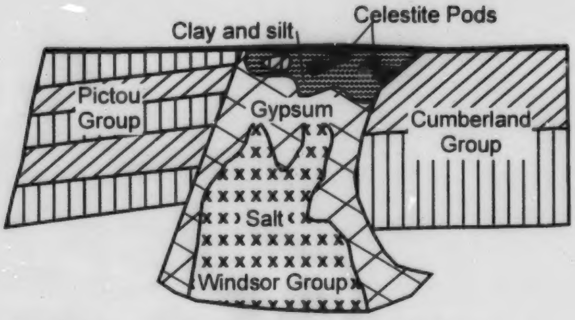


Figure 4. Schematic cross-section of the Beckwith property showing the celestite pods with clay and silt derived from karstification of Windsor Group rocks.

petroleum, but no evidence of petroleum was found.

Fluid Inclusion Thermometry

Measurements reported below were made on single, isolated inclusions and groups of inclusions concentrated along healed fracture planes and rare growth zones. Initial measurements of homogenization temperatures suggested results were unreliable for the following reasons. (1) Homogenization temperatures were considerably higher than expected given the L:V ratio of inclusions and assuming a simple aqueous system (Roedder, 1984), which suggested that stretching occurred in the inclusions during heating (Bodnar and Bethke, 1984). (2) Results varied widely for a fluid inclusion assemblage, given their similar L:V ratios. Thus, the results reported below are restricted to observations made during freezing runs only.

Inclusions were frozen to -100 to -120°C and subsequently observed during controlled heating until all phases had melted. During freezing, the vapor bubble froze suddenly (i.e. collapsed) at ca. -40°C to -52°C with the exception being two isolated inclusions that froze at -35 and -30°C (Fig. 6a). In exceptionally large L-V inclusions (ca. 100 µm) and large (ca. 30-50 µm) V-rich inclusions, freezing of the vapor phase was observed specifically to examine for evidence of condensed gases such as CH_4 or CO_2 (e.g. clathrate development). However, the only phase observed during freezing was formation of ice along edges of the V-phase. During warming the majority of inclusions first darken and then become grainy in appearance before developing an onionskin-type texture in the -55° to -50°C range, which is generally considered indicative of recrystallization and initial melting (Goldstein and Reynolds, 1994). In the -40° to 45°C range, definite melting occurs with ice coexisting with abundant, small, high-relief microlites considered to be hydrohalite (HH). The HH phase persists until -26° to -22°C (Fig. 6b). In a few large inclusions (to 100 µm), temperature cycling (see Goldstein and Reynolds, 1994) was performed and in these cases hydrohalite melting was easily observed and it dissolved at -22°C. Ice is the last phase to melt in all the inclusions; melting occurs between -16.5° to -0.1°C, with the majority above -8.0°C (Fig. 6c). In those inclusions where HH was not observed, first melting occurs near -8° to -3°C with subsequent rapid melting of ice.

Fluid Composition from Thermometry

The composition of the fluid phase is inferred from the freezing and melting of inclusions and comparison to modelled chemical systems (Roedder, 1984; Goldstein and Reynolds, 1994; Bodnar and Vityk, 1994). Freezing runs indicate that condensed gases such as CO_2 and CH_4 are not present, since neither double freezing of the inclusions nor clathrate formation were noted. Crushing of inclusions confirms the absence of detectable condensed gases. The development of graininess and onionskin texture, and clear melting in the -50° and -40°C range, suggest the presence of solute(s) other than Na in order to depress the eutectic point in the $NaCl-H_2O$ system (-21.2°C; Sterner *et al.*, 1988). Less reliable, but empirically valid, is the depressed point of freezing of inclusions in the -40° to -55°C range, which is well below what is normally observed for fluid inclusions in the $NaCl-H_2O$ system. Although the observations are suggestive of $CaCl_2$, the melting of hydrohalite and ice suggests low $CaCl_2/(CaCl_2+NaCl)$ ratios (ca. <0.2), based on phase equilibria in the $CaCl_2-NaCl-H_2O$ system (Vanko *et al.*, 1988; Oakes *et al.*, 1990). In the few large inclusions that were cycled, the melting of HH at -22°C is only slightly below the eutectic in the system $H_2O-NaCl$ (i.e. -21.2°C). Thus, for the inclusions examined the fluid is clearly dominated by NaCl with only minor amounts of another solute, probably $CaCl_2$.

Fluid salinities, as equivalent wt. % NaCl, were calculated using the equation of Bodnar (1993; table in Bodnar and Vityk, 1994). Salinities range from 0.2 to 19.8 wt. % eq. NaCl, but the majority fall below 11 wt. % eq. NaCl with a continuum down to near 0 wt. % (Fig. 6c). These salinities are noted to be significantly lower than most Carboniferous Pb-Zn-Ba-F assemblages in a variety of occurrences in Nova Scotia (e.g. Ravenhurst *et al.*, 1989; Kontak, 1998; Chi and Savard, 1995; Chi *et al.*, 1995; Kontak and Macdonald, 1995; Kontak and Sangster, 1998).

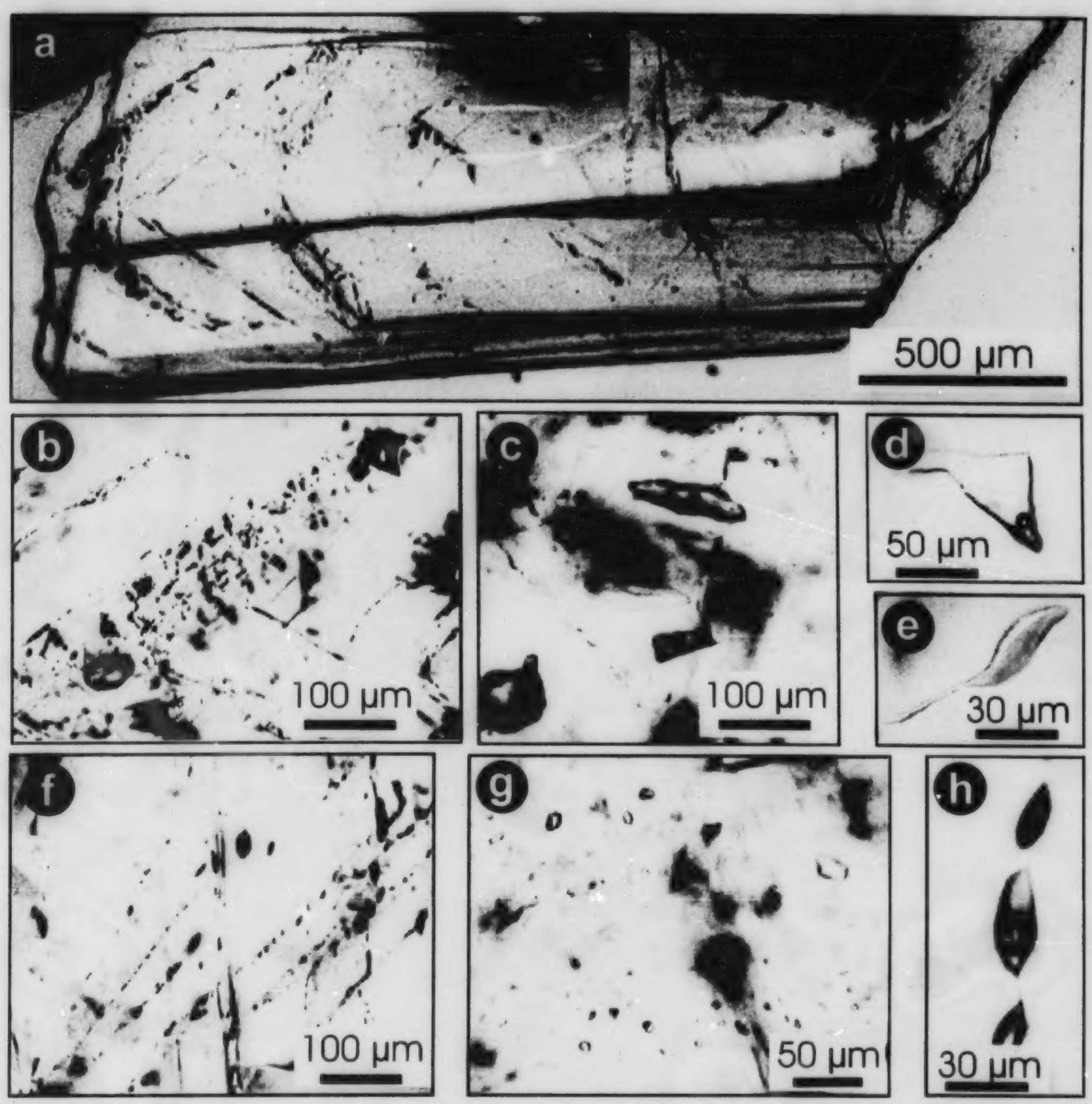


Figure 5. Photomicrographs of fluid inclusions in celestite from Beckwith. (a) Celestite chip showing primary growth zones decorated by fluid inclusions. (b) Growth zone in celestite with primary fluid inclusions. Note the irregular shapes of the inclusions and V-rich nature. (c) Large, randomly oriented L-V and V-rich inclusions in celestite. Note healed fracture planes with smaller inclusions in the background. (d) Isolated L-V inclusion. Cycling of this inclusion indicated hydrohalite melting at -22°C and ice melting at -2.8°C. (e) Tadpole-shaped, L-rich inclusion that originated from necking down. (f) Secondary fluid inclusions decorating a series of subparallel healed-fracture planes in celestite. (g) Planes of secondary fluid inclusions in celestite. Note that most of the inclusions are equant with negative crystal shapes. (h) Example of necked fluid inclusion which is now three separate inclusions with variable L:V ratios (top to bottom: V-rich, L+V, V-rich).

Fluid Inclusion Decrepitate Analysis

Analysis of fluid inclusion decrepitate mounds (Haynes *et al.*, 1988) was carried out to complement the thermometric data discussed above. Decrepitate mounds were first imaged and then analyzed using an energy dispersive system (EDS) with a 1-10 µm electron beam. Imaging of the samples indicates the presence of open cavities without associated mounds and also ones with mounds (Fig. 7b, c). Whereas the latter reflect precipitation of solutes from saline inclusions, the former probably represent evacuated inclusions with very low salinities (i.e. 0 wt. % eq. NaCl; see Fig. 6c). Results of EDS analysis of the mounds indicate three chemically distinct groupings (1, 2, 3), as summarized in the Si-Ca-Na and Cl-Ca-Na ternary plots of Figure 8. Group 1 consists of Na-Ca-Cl mounds which also have erratic amounts of Mg ($\leq$3-4 wt. %), K ($\leq$1-2 wt. %) and Ba ($\leq$1 wt. %). Group 2 consists of Ca-Si mounds with erratic Ba ($\leq$3 wt. %) and without detectable amounts of either Mg or K. Finally, group 3 consists of Si-rich mounds with minor amounts of Ca and a noted absence of any Cl. The proximity of these different mounds to each other is illustrated in Figure 9, which shows groups 1, 2 and 3 mounds within an area of ca. 0.015 mm^2.

A chemically unusual type of mound was encountered during routine analysis of the decrepitates. These mounds, shown in Figure 7a, are enriched in Ni (to 62 wt. %) and Fe (to 36 wt. %), have variable Si and Ca, and are deficient in Cl. Hence, these mounds equate to group 2 mounds mentioned in the paragraph above.

Summary of Fluid Inclusion Data

Thermometric measurements of fluid inclusions and analysis of decrepitate mounds hosted by celestite indicate a variety of fluids infiltrated the mineralized site at Beckwith. These fluids are variably saline with 0 to 18 wt. % eq. NaCl, and semiquantitative analyses indicate three distinct chemical groups, namely Na-Ca (-K-Mg-Ba), Ca-Si(-Ba), and Si. Unfortunately, it is not possible at present to discern temporal or spatial relationships among these different fluid types. We also note the presence of the unusual Ni- and Fe-rich fluids, as

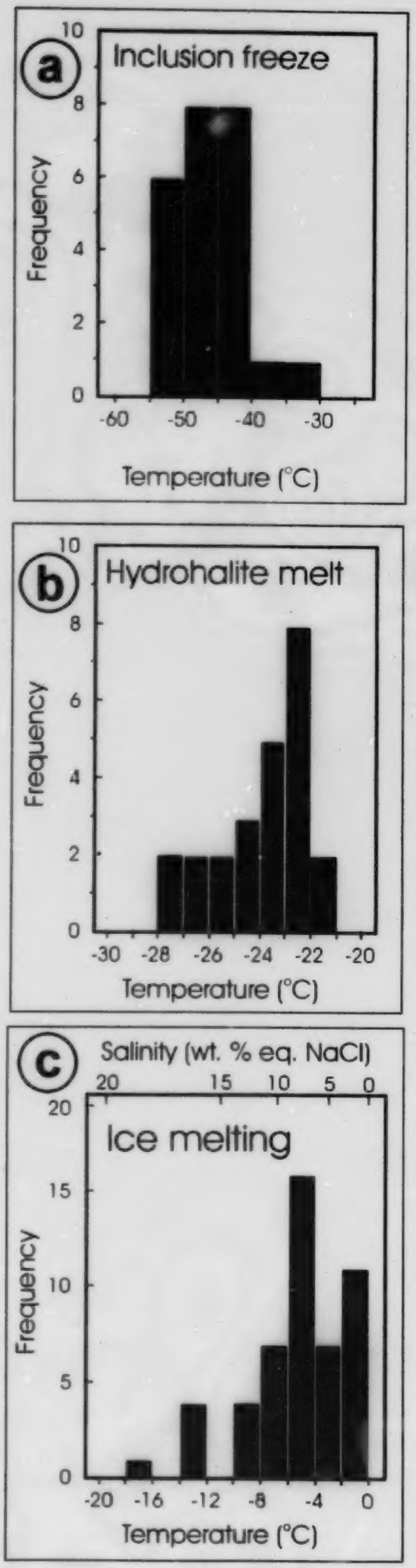


Figure 6. Histogram plots summarizing thermometric data for fluid inclusions hosted by celestite from Beckwith. (a) Temperature at which inclusions freeze during cooling, a determined by sudden collapse of vapor phase in the inclusions. (b) Temperature of dissolution of hydrohalite in fluid inclusions. (c) Temperature of ice melting in fluid inclusions.

indicated from the decrepitate analysis, which have not been noted previously in Carboniferous mineral deposits of Nova Scotia.

Discussion

The occurrence of isolated pods of massive celestite in a clay unit containing spores of Windsor Group age is unusual. Elsewhere in Nova Scotia celestite occurs either as a replacement of carbonate rocks or as veins. The clay host itself is not typical of the Windsor Group strata, which are known to lack thick clay units. Instead, the mottled and unconsolidated nature of the host clay beds is consistent with what one might expect to see in a residuum derived from karstification of the Windsor Group evaporites due to infiltration of either basinal fluids or descending surficial water. The Windsor Group gypsum and anhydrite units contain an average of 800 ppm Sr and have been found to contain as high as several thousands of ppm Sr (Adams, 1991). Therefore, dissolution of the evaporitic beds would result in liberation of considerable quantities of Sr in solutions that would also be enriched in Ca and SO_4.

Fluid inclusion studies indicate that the fluids present in celestite are of variable salinity (i.e. 0 to 18 wt. %) and of mixed chemistry (Na-Ca-Si-Cl). The chemistry of these fluids can be explained by the alteration of the surrounding clastic and evaporitic strata. In general, the fluids are similar to basinal brines associated with carbonate-hosted Zn-Pb-Ba-F mineralization in Maritime Canada, although the salinities are slightly lower (Chi and Savard, 1995; Chi *et al.*, 1995; Sangster *et al.*, 1998). However, the Si-rich nature of the fluids, in addition to traces of Ni and Fe, are noted to be anomalous and differ in this respect from the fluids associated with Carboniferous mineralization in Nova Scotia where decrepitate analyses are available (Savard and Chi, 1998; unpubl. data of Kontak). This difference may relate to the formation of kaolinite in the clastic strata given the low temperature of fluid:rock interaction and formation of kaolinite during alteration, which would liberate Si. The Ni and Fe may reflect breakdown of nickeliferous pyrite in the redbed sequences of the Cumberland Group.

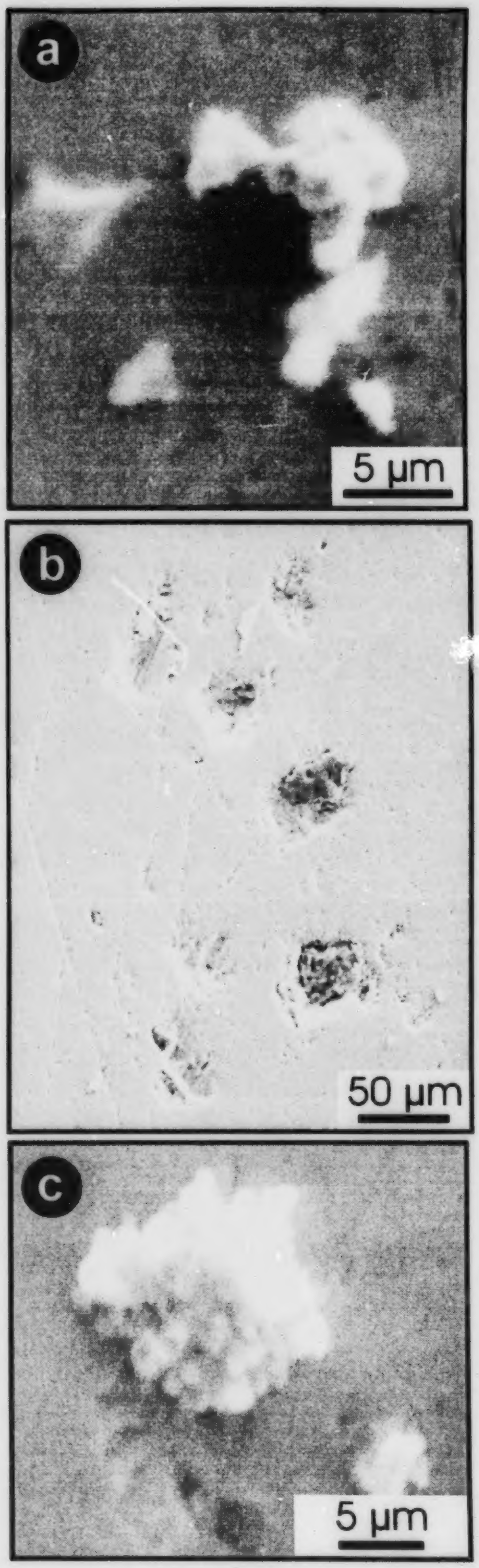


Figure 7. Combined secondary electron and back scattered electron images of different features of decrepitated fluid inclusions hosted by celestite. (a) A Ni-, Fe-, Si- and Ca-type decrepitate mound. (b) Empty cavities without proximal mounds possibly indicating that a very low salinity brine once occupied the inclusions. (c) A Na-, Ca-, K-, Cl-type decrepitate mound. Note the distinct, sub-micron scale crystal-like features that comprise this mound.

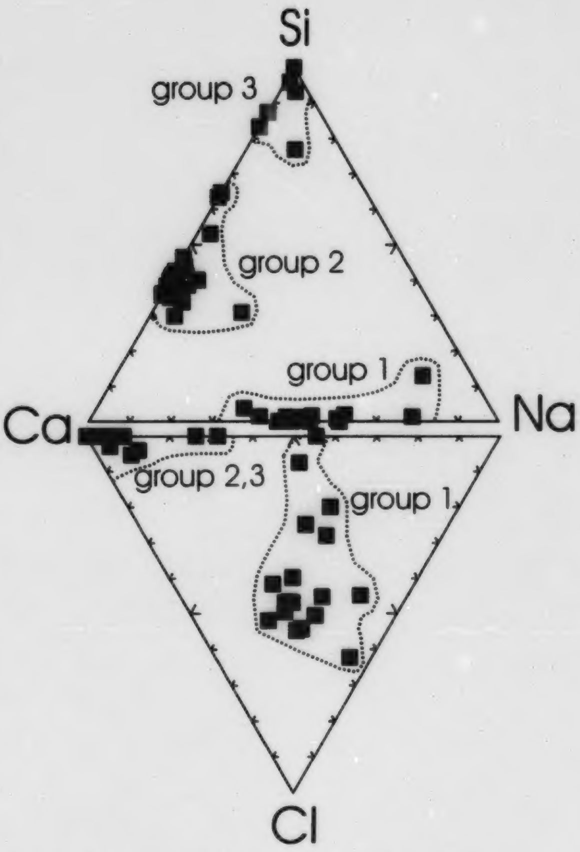
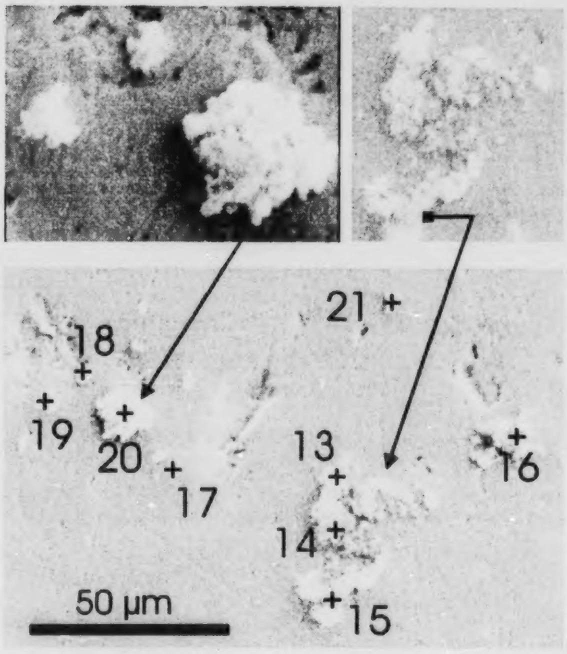


Figure 8. Ternary plots of Ca-Si-Na and Ca-Cl-Na illustrating the chemistry of the decrepitate mounds in celestite. Note that three distinct chemical groupings, designated group-1, 2, and 3, are distinguished.

A preliminary model, therefore, for the celestite mineralization involves karstification of the evaporites due to infiltration of groundwater and/or basinal brines along fault zones. The fluids would have interacted with the permeable red sandstone surrounding the Windsor Group strata in the area. Water moving through the red sandstone was likely oxidizing and carried Si and Pb derived from the kaolinization of feldspars in the sandstone, as well as Fe and Ni derived from the oxidation of the Ni-bearing, early diagenetic pyrite common in the Upper Carboniferous strata of the Cumberland Basin (Ryan and Boehner, 1994; Fig. 4). Given that the essential components of this model are present throughout the study area, additional centres of celestite mineralization might be expected.

The age of dissolution of the Windsor Group evaporites would provide a constraint on the timing of mineralization, but this is difficult to constrain given that the history of karstification is complex, multigeneration, and has occurred over a long period of time. The best that can be offered at this time is that a maximum age for the event is Permian, which coincides with the age of redbed copper mineralization that may have been remobilized to give the anomalous Ni-Fe signature of the fluid inclusions.



mound	chemistry
13	Si(Ca)
14	Ca-Si
15	Ca-Si
16	Ca-Si
17	Ca-Si(Na)
18	Ca-Na-

Figure 9. Combined secondary electron and back scattered electron images of decrepitate mounds with corresponding chemistry, as determined by electron microprobe analyses. Note that the three groupings identified in previous Figure are distinguished in this area.

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Geoscience Editing and Publishing

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Publications play an important role in delivering geoscience information for the Minerals and Energy Branch, educating the public, and conveying the professional image established by the branch. A publication is often the first chance we have to make an impression on someone who comes into contact with the Department of Natural Resources.

Staff of the geoscience editing and publishing group work toward the goal of consistent high-quality, timely, and cost-effective reporting on activities carried out by the Minerals and Energy Branch. All geoscientists in the Branch are required to publish accounts of their work. These accounts may be published as scientific reports, memoirs or maps, or they may best be communicated in less technical publications such as information circulars or newsletters. The Branch newsletter *Nova Scotia Minerals Update* is produced quarterly and distributed to approximately 1600 subscribers around the world. The newsletter and many other publications are also converted to HyperText Markup Language (HTML) or Acrobat® PDF and are available on-line as part of the Minerals and Energy Branch web site. These activities ensure that current geoscience information on Nova Scotia is readily available to enhance public awareness and to promote the mineral resources of the province.

The role of the geoscience editing and publishing group in the Geoscience Information Services Section can be roughly divided into two parts. The first part involves editing a manuscript (report, article or map) to the author's satisfaction, while at the same time applying the branch standards for style and content in the interest of our readers. Editor Doug MacDonald and contract editor Kathy Mills carry out this work for the Minerals and Energy Branch. The second part involves producing a published document. The editors work with word processing operators Barb MacDonald and Susan Saunders to produce publications.

Editing

In the Minerals and Energy Branch, all scientific publications must be reviewed by at least one scientist who has not contributed to the research being presented. This process is called peer review and finding a suitable reviewer is usually the editor's first task after receiving a manuscript. The editor assigns the manuscript to a reviewer who is experienced in the field of study being presented by the author. The editor supplies the reviewer with detailed guidelines to direct the review toward the most critical scientific aspects of the manuscript. The reviewer's comments are then given to the author so that the manuscript can be revised in an effort to improve its scientific content. Open File Reports and Open File Maps are used to release information as soon as possible, and may be approved for publication after peer review, revision by the author and minimal editing.

Resubmission of the manuscript by the author after peer review initiates the next step in the editorial process, often called substantive editing. This step may require re-writing parts of the document, re-organizing sections, and generally suggesting ways that authors can improve the presentation of their research for the intended readers. The relationship between author and editor is most important during this phase of substantive editing.

Another aspect of the editorial process is often referred to as copy editing. This function requires careful attention to every detail in a document in order to meet the Branch publication standards. For the Minerals and Energy Branch, these standards reflect those used by the Geological Survey of Canada. Some standards, such as consistent capitalization, spelling and punctuation, are easily applied. Others may require much more time and effort, such as accurate citation and listing of references, and making sure that tables, maps and drawings meet the appropriate specifications.

Publishing

The final appearance of a publication is largely determined by the publication team, which includes an editor and a word-processing operator. In the age of computer-based publication, the job title 'word processing operator' is a throw-back to the days of the first machine to replace typewriters, the word processor. This function now consists of preparing camera-ready (or Internet-ready) manuscripts for publication, and involves words, figures, tables and other design elements that are electronically composed using a variety of publishing applications, such as Word®, WordPerfect®, Publisher® and Acrobat®. Manuscripts travel back and forth between the editor and the word processing operator many times before they are ready to be published, either on paper or on-line.

The following publications were released in 2000:

Contribution Series

CS ME 2000-1 Petroleum system of the Carboniferous sediments of onshore Nova Scotia, by P. K. Mukhopadhyay, D. J. MacDonald, P. J. Harvey, R. C. Boehner and R. J. Ryan; *in* International Journal of Coal Geology, v. 43, p. 137-139.

CS ME 2000-2 Zn-Pb mineralization associated with a mafic dyke at Cheverie, Hants County, Nova Scotia: implication for Carboniferous metallogeny, by D. J. Kontak, K. Ansdell and D. A. Archibald; *in* Atlantic Geology, v. 36, p. 7-26.

Information Circular

IC ME 56 A users guide to the "One Window" process for mine development approvals, compiled by Mineral Development and Policy Section, 34 p.

IC ME 60 Properties Available for Option in Nova Scotia, January 2000, 55 pages.

Maps

Map ME 2000-1 Geological map of the Province of Nova Scotia, compiled by J. D. Keppie, scale 1:500 000.

Map ME 2000-2 Enhanced aeromagnetic and digital elevation map of eastern Nova Scotia, compiled by M. S. King, scale 1:125 000.

Newsletter

Nova Scotia Minerals Update, volume 17, numbers 1, 2, 3 and 4.

Open File Illustration

OFI ME 2000-1 Active mining operations in Nova Scotia, compiled by Mineral Development and Policy Section.

Open File Maps

OFM ME 2000-1 Land designation and ownership in Nova Scotia, compiled by D. B. Hopper, F. J. Bonner and B. E. Fisher, scale 1:500 000.

OFM ME 2000-2 Map of active mines in Nova Scotia, compiled by I. M. MacLellan, scale 1:1 000 000.

OFM ME 2000-3 Preliminary geological map of the Wolfville-Windsor area, Hants and Kings Counties, Nova Scotia (NTS 21H/01 and parts of 21A/16 C and D), compiled by R. G. Moore, S. A. Ferguson, R. C. Boehner and C. M. Kennedy, scale 1:50 000.

OFM ME 2000-4 Mineral resource land-use map of Nova Scotia, compiled by D. B. Hopper, F. J. Bonner, B. E. Fisher and A. N. Murphy. Released as 89 individual 1:50 000 scale NTS map sheets.

OFM ME 2000-6 Mineral rights disposition map for the Province of Nova Scotia, compiled by B. E. Fisher, I. M. MacLellan and A. S. Wenning, scale 1:500 000.

OFM ME 2000-7 Designated underground gas storage exploration areas in the Province of Nova Scotia, compiled by B. E. Fisher, I. M. MacLellan and A. S. Wenning, scale 1:500 000.

OFM ME 2000-8 Geothermal resource areas in the Province of Nova Scotia, compiled by B. E. Fisher, I. M. MacLellan and A. S. Wenning, scale 1:500 000.

Open File Reports

OFR ME 2000-1 NTS location, author and citation index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch assessment reports, 1996-1999, compiled by P. D. McCulloch, S. Marshall, N. A. Lyttle and J. S. Saunders, 1999, 116 p.

OFR ME 2000-2 Mineralogical analyses of till samples from northern Nova Scotia, compiled by R. R. Stea, 200 p.

OFR ME 2000-3 Limestones and dolomites of Nova Scotia, Part 3, Colchester and Halifax Counties, by D. A. Murray, 181 p.

Reports

Report ME 2000-1 Minerals and Energy Branch Report of Activities 1999, eds. D. R. MacDonald and K. A. Mills, 268 p.

Report ME 2000-2 Mining Matters for Nova Scotia 2000: Opportunities for economic development, ed. D. R. MacDonald, 42 p.

Mineral Exploration in Nova Scotia, 2000

P. D. McCulloch

Mineral Exploration Monitoring

Monitoring of mineral exploration activity in Nova Scotia is coordinated through the Registry of Mineral and Petroleum Titles, Minerals Management Division, by the author who works out of the regional office in Stellarton, Pictou County. Regional Geologists of the Regional Services Branch offices in Coxheath (Don MacNeil), Truro (Ian Lawyer) and Bridgewater (Sandra Marshall) assist in the field monitoring of mineral exploration activity in their respective regions.

The monitoring process covers exploration activities throughout the province and consists of visits to company offices and exploration sites, liaison with industry personnel, and the review of current assessment reports and other material submitted by industry. Liaison with industry allows the department to maintain an awareness of current exploration activities throughout Nova Scotia. Assistance or advice is provided as necessary, and any drill core generated by mineral exploration activity is recorded as part of the monitoring process. This core may be recovered for archiving in the Drill Core Library in Stellarton when no longer required by the companies.

The Exploration Monitoring geologist is also responsible for the auditing of confidential assessment reports that are submitted in the support of the renewal of exploration licences. In 2000, 86 assessment reports were received and audited for compliance with the Mineral Resources Regulations.

Exploration Activity

Mineral exploration in Nova Scotia during 2000 has continued at approximately the same level of activity as in 1999. The level of field exploration expenditures has continued to decline over the past three years with field expenditures expected in the range of $3-4 million for 2000, compared with $3.8 million in 1999 and $5.6 million in 1998 (Table 1, Fig. 1). Exploration focused primarily on industrial minerals, and to a lesser extent on base metals and gold. In this regard, interest in the exploration and development of industrial mineral commodities has strengthened in recent years, whereas activities related to the exploration and development of base metals and gold has been on the decline, due primarily to low commodity prices for metals and the difficulty in raising venture capital to fund exploration programs.

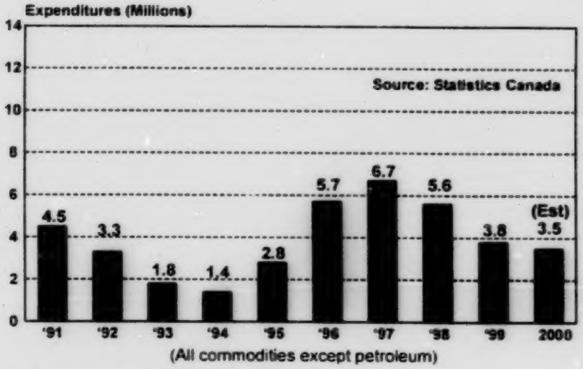


Figure 1. Exploration expenditures in Nova Scotia, 1991-2000.

Preliminary figures for the total number of general claims staked in 2000 show a decrease of 27.5% from the previous year to 10,175 (Table 1, Fig. 2). A preliminary total of 10,242 claims for all commodities were in effect at the end of 2000 represented by 570 exploration, coal, tailings and special licences covering an area of 165 797 ha or 1 658 km^2, approximately 3.0% of the total area of the province. The amount of exploration drilling also decreased in 2000 with a preliminary estimate of 8 500 m compared with 13 300 m in 1999 and 10 300 m in 1998.

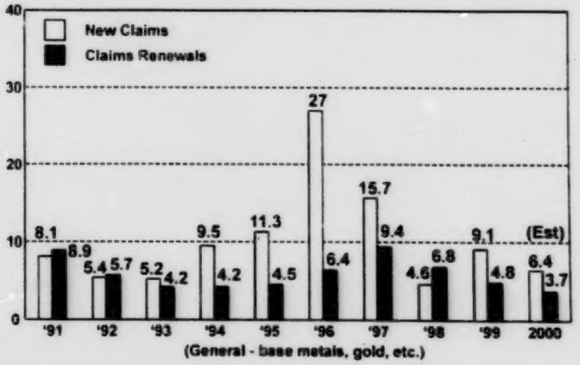


Figure 2. Claim staking in Nova Scotia, 1991-2000.

Table 1. Details of exploration and development activity in Nova Scotia, 1991-2000.

	1991	1992	1993	1994	1995	1996	1997	1998	1999	^{p}2000
Total Field Exploration Expenditures ($)	4 532 000	3 300 000	2 300 000	1 400 000	2 843 000	5 752 000	6 700 000	5 600 000	3 800 000	3 500 000
Total Licences Issued (all categories)	642	507	593	671	698	1 126	977	709	704	570
Claims In Good Standing (new and reissued)										
General	17 071	11 157	9 504	13 740	15 861	33 399	25 190	11 452	14 045	10 175
Special (Order in Council)										
Salt and Potash	264	264	66	66	-	16	16	329	74	-
Coal	1 566	366	433	376	376	469	398	253	173	-
Tailings	116	94	146	146	146	146	146	-	-	-
Other	448	348	452	255	130	254	254	621	623	67
Uranium*	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)	(226)
Development	553	-	-	-	-	-	-	-	-	-
Total (excluding closures and uranium licences)	20 018	12 229	10 601	14 583	16 513	34 284	26 004	12 655	14 915	10 242
Total Area Held Under Licence										
(ha)	324 051	197 963	171 609	236 069	267 312	554 988	420 952	204 859	241 444	165 797
(acres)	800 720	489 160	424 040	583 320	660 520	1 371360	1 040 160	506 200	596 600	409 680
Work Reported for Licence Renewals ($)	3 889 914	2 333 972	983 402	1 694 368	1 601 639	2 376 023	3 146 899	5 385 194	2 969 047	1 136 304
Number of Assessment Reports Received	132	75	62	84	111	108	133	134	101	86

Table 2. Major companies involved in mineral exploration in Nova Scotia.

	1998	1999	2000	Office location in 2000
BHP Minerals Canada Limited	-			
A. J. Perron Gold Corporation (formerly Deak Resources Corporation)	x			
Falconbridge Limited	-			
Fundy Gypsum Company Limited	x	x	x	Windsor
Georgia Pacific Corporation	x	x	x	Sugar Camp
Lafarge Canada Incorporated	-	x	x	Brookfield
Little Narrows Gypsum Company Limited	x	x	x	Little Narrows
National Gypsum (Canada) Limited	x	x	x	Milford Station
Noranda Exploration Company Limited	-	-	-	
Phelps Dodge Corporation of Canada Limited	x			
Pasminco Resources Canada Company (formerly Savage Resources Canada Limited)	x	x	x	
Statia Terminals Canada Limited	x	x	x	
W. M. C. International Limited	-	-	-	

x indicates work performed
- company inactive
blanks indicate that the company did not hold an exploration licence in that particular year

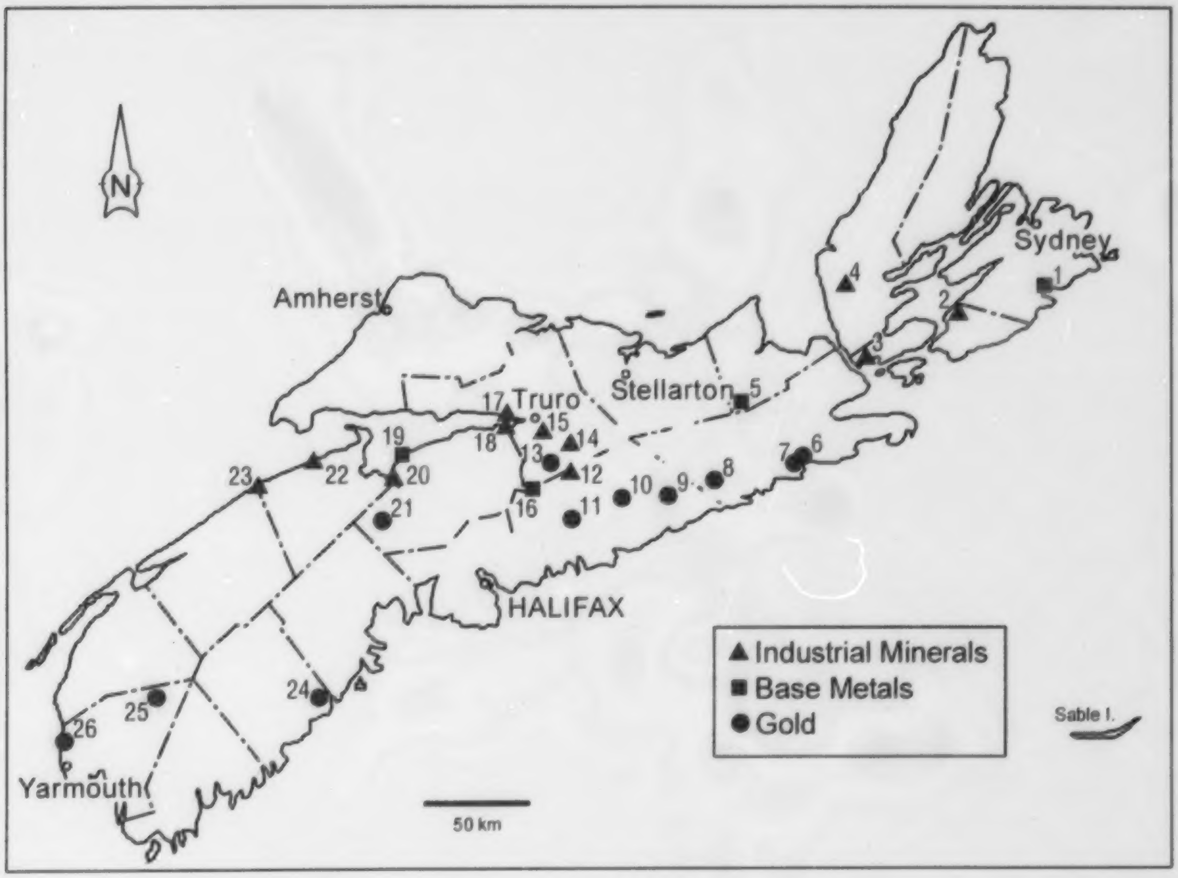
Approximately 237 companies and individuals held exploration interests (licences or options) in Nova Scotia in 2000, including 10 major, 8 junior and 56 private companies (Tables 2, 3 and 4). In addition, several mining leaseholders carried out exploration on their leases or on unclaimed ground where these commodities did not require licences (e.g. limestone, gypsum). Organizations actively engaged in exploration during 2000 included 7 major, 4 junior and 15 private companies (Fig. 3, Table 5), as well as a number of individuals.

Industrial Minerals

Exploration and development work for industrial minerals was undertaken for several commodities including kaolin, silica sand, limestone, gypsum, zeolites, titanium and barite. Work continued to focus primarily on the development of kaolin and silica sand deposits, both in the central mainland area of the province and in the Flintstone Rock area, Yarmouth County. Work also continued in an effort to evaluate the zeolite potential of the North Mountain basalt along the southern margin of the Bay of Fundy, as well as the potential for commercial deposits of titanium-bearing sands along the Shubenacadie River in northern mainland Nova Scotia.

Kaoclay Resources Incorporated continued a detailed evaluation of Cretaceous kaolin and silica sand deposits in the Musquodoboit and Shubenacadie valleys of central mainland Nova Scotia. The company completed extensive diamond-drilling on the Sibley Road prospect in the Middle Musquodoboit area late in 1999 and have recently been conducting detailed analytical studies at Kaoclay's pilot plant in Georgia (USA).

Black Bull Resources Incorporated, under an option agreement with CAG Enterprises Limited, continued a detailed exploration program for kaolin and silica in an altered quartz-kaolinite breccia zone along the Tobeatic Shear Zone in the Flintstone Rock area, Yarmouth County. The company completed trenching and preliminary bulk sample testing early in the year followed by additional diamond-drilling and large-scale bulk sampling during the fall.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Amherst
Stellarton
Truro
HALIFAX
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1. Tom Faulkner/Dennis Forgeron
2. Robert MacDonald
3. Statia Terminals Canada Ltd.
4. Glencoe Resources Inc.
5. Goliath Copperfields Ltd.
6. Gold 'n Crystal Minerals
7. Joseph Collier
8. Thomas Baillie
9. Dufferin Mines Inc.
10. Gold 'n Crystal Minerals
11. Strikezone Minerals (Canada) Ltd.
12. KaoClay Resources Inc.
13. Joseph Collier
14. KaoClay Resources Inc.
15. Votix Corporation Ltd.
16. Pasminco Resources Canada
17. Martin Roche
18. NAR Resources Ltd.
19. Geosearch
20. Hansone Ltd.
21. True Metallic Explorations Inc.
22. C$_2$C Mining Corporation
23. C$_2$C Mining Corporation
24. Lindsay Allen
25. Black Bull Resources Inc.
26. Hubert Burrill

Figure 3. Mineral exploration programs in Nova Scotia, 2000.

Table 3. Junior exploration companies in Nova Scotia, 1998-2000.

	1998	1999	2000	Office location in 2000
Black Bull Resources Incorporated		x	x	
C_2C Mining Corporation	x	x	x	Kentville
Corner Bay Minerals Incorporated	-	-	-	Cold Brook Station
Exploration Orex Incorporated	-		-	
Globex Mining Enterprises Incorporated	-	-	-	
Groundstar Resources Limited	-			
Heartland Resources Limited	-	-	-	Dartmouth
NAR Resources Limited		x	x	
Regal Goldfields Limited	x	-	-	
Roycefield Resources Limited	-	-	-	
RJZ Mining Incorporated	x	x	-	
Titanium Corporation of Canada Limited		x	x	

x indicates work performed
- inactive
blanks indicate that the company did not hold an exploration licence in that particular year

C_2C Mining Corporation continued a detailed evaluation of the zeolite potential of amygdaloidal basalts along North Mountain in western Nova Scotia. The company completed additional diamond-drilling on their Stronach Mountain property in Annapolis County and in the Ross Corner area in Kings County.

NAR Resources, under an option agreement with Titanium Corporation of Canada Limited, continued to evaluate the titanium potential of heavy mineral sands in the Shubenacadie River near Maitland, Hants County. The company completed additional heavy minerals sampling and metallurgical studies during the summer. Mr. Martin Roche, in association with Hansone Limited, continued a detailed evaluation of the heavy mineral potential of sand deposits in the Cobequid Bay area near Maitland, Hants County, and in the Avon River area near Windsor, Hants County. Mineralogical analyses and processing tests were completed on samples from vibracore drilling carried out on the two areas during the year.

Glencoe Resources Incorporated continued a detailed evaluation the Glencoe carbonate deposit near Glencoe, Inverness County. The company carried out additional lithological sampling on the property along with detailed physical and chemical analyses.

Mr. Robert MacDonald continued a detailed evaluation of the former Novex Mining Pine Brook barite deposit at Lochside, Richmond County. Additional diamond-drilling was completed on the property late in the year. Votix Corporation Limited conducted a preliminary sampling program on the Middle Stewiacke barite property to evaluate the development potential of discarded dump material in the vicinity of the old workings.

Base Metals

Exploration for base metals in 2000 continued at approximately the same level of activity as in 1999 and focused primarily on areas of known mineral occurrences, primarily in the northern mainland area of the province.

Goliath Copperfields Limited initiated a detailed evaluation of the base metal potential in the vicinity of known mineral occurrences in the College Grant, Lochaber Lake and Cross Roads Ohio areas along the southeastern boundary of the Antigonish Highlands. The company completed an airborne geophysical survey over the area in the late spring with follow-up drilling completed in the College Grant area during the fall.

Table 4. Private exploration companies in Nova Scotia, 1991-2000.

	1998	1999	2000	Office location in 2000
166881 Canada Incorporated			-	
3779751 Canada Incorporated			-	
Atlantic Industrial Minerals Limited	-	-	-	
Asedex Minerals Corporation Limited		-		
Aurion Minerals Limited		-	-	
Broad River Exploration		-		
Burnt Point Resources Incorporated	x	x	-	Halifax
C.A.G. Enterprises Limited	-	x	x	Antigonish
Cannova Goldfields Incorporated		x		
Cape Minerals Limited	-	-		
Champlain Resources Incorporated	-	-		
Cobequid Life Sciences Limited	-	-		
Conrad Brothers Limited		-		Dartmouth
D&D Metal Detectors Limited		-	-	
D. R. Duncan & Associates Limited		-		
Datum Quest Explorations		x	-	
Dufferin Resources Incorporated	-	x	x	Halifax
Earth Search Sciences. Incorporated			-	
Ellsin Resources Incorporated	x	x	x	
Gallant Aggregated Limited		-	-	
Gammon Lake Resources Incorporated	x	-		Halifax
Geocol Mining & Exploration		-	-	
Geosearch	x	x	x	Sackville
Giant Meguma Holdings	-	-		Halifax
Glencoe Resources Incorporated			x	
Gold Bank Resources Limited	-			
Gold 'n' Crystal Minerals	x	x	x	East Advocate
Golden Ace Mineral Explorations Limited	x	x	x	
Goliath Copperfields Limited	x	-	x	
Groundstar Resources Limited	-			
Gusto Resources Limited	-			Halifax
H & E Mullen Investments Limited		-	x	
Hansone Limited	x	x	x	
Hibernia Minerals Incorporated		-	-	
Highland Range Minerals Limited	x	-	-	
Huntington Explorations Incorporated	-	-	-	
Intragaz & Company Limited Partnership	-	-	-	
James Henry & Associates	-			
John Logan Enterprises Limited	-	-		
Jubilee Minerals	x	x	-	Bedford
KaoClay Incorporated	x	x	x	Milford Station
Kelly Investments Limited		-	-	
Kelly Rock Limited	-	x	-	Sydney
Lake Annis Properties Limited	-			
Little Lake Gold Mines Limited	-	-	-	Dartmouth
Lynx Minerals Corporation		x	x	

Table 4. continued.

	1998	1999	2000	Office location in 2000
Maritime Mica Incorporated	x	-	-	
Mercator Geological Services Limited	x	x	-	Dartmouth
Minas Basin Pulp & Paper Company Limited		-		
Mineral City Enterprises Incorporated			-	
Mount Cameron Minerals Incorporated		x	-	
Mountain Lake Resources Incorporated	-			
New Road Resources Limited	-			
North Cape Breton Resources Limited	x	-	-	
Ochter Holdings Limited		-	-	
Pan East Petroleum Corporation (formerly Pan East Resources Incorporated)	-	-	-	
Prodigy Resources Incorporated	-	-	-	
Rainbow Resources Limited		-	-	
Remoscan Limited	-	x		
Renfrew Holdings Limited	-			
The Shaw Group Limited (formerly L. E. Shaw Limited)		x	x	Lantz
Strikezone Minerals (Canada) Limited	x			
Tangier Limited Partnership (formerly Tangier Mining Incorporated)	x	-		Tangier
Tri-Explorations Limited	x	-		Halifax
True Metallic Explorations	x	x	x	
Uravan Minerals Incorporated		-		
Votix Corporation Limited	x	x	x	Trenton

x indicates work performed
- inactive
blanks indicate that the company did not hold an exploration licence in that particular year

Table 5. Exploration programs in Nova Scotia, 2000.

COMPANY/INDIVIDUAL	LOCATION	COMMODITY	PROGRAM	STATUS
Black Bull Resources Incorporated	Flintstone Rock, Yarmouth County	Kaolin, silica sand	Diamond-drilling, trenching, bulk sampling	Ongoing
C_2C Mining Corporation	Stronach Mountain, Annapolis County Ross Corner, Kings County	Zeolites Zeolites	Diamond-drilling Diamond-drilling	Ongoing -
Dufferin Mines Incorporated	Dufferin Mines, Halifax County	Gold	Underground development work	-
Geosearch	Cheverie, Hants County	Base metals	Prospecting, geochemical sampling	Ongoing
Glencoe Resources Incorporated	Glencoe, Inverness County	Limestone	Lithogeochemical sampling	Ongoing
Gold'n Crystal Minerals	Isaacs Harbour, Guysborough County	Gold	Prospecting, geochemical sampling, geochemical surveys	Ongoing
Gold'n Crystal Minerals	Killag Mines, Halifax County	Gold	Geochemical sampling	-
Goliath Copper Fields Limited	Lochaber Lake	Base Metals	Geological mapping, airborne geophysics trenching, diamond-drilling	-
Goliath Copper Fields Limited	College Grant	Base Metals	Diamond-drilling	-
Hubert Burrill	Pembroke, Yarmouth County	Gold, placer	Vibra-core drilling	Completed
Joseph Collier	Isaacs Harbour, Guysborough County	Gold	Prospecting, geochemical sampling	-
Joseph Collier	South Branch, Colchester County	Gold	Prospecting, geochemical sampling	-
KaoClay Resources Incorporated	Middle/Upper Stewiacke	Clay, silica sand	Analytical studies	Ongoing
KaoClay Resources Incorporated	Middle/Upper Musquodoboit	Clay, silica sand	Analytical studies	Ongoing
Lindsay Allen	Mill Village, Queens County	Gold	Prospecting, trenching	Ongoing
Martin Roche/Hansone Limited	Cobequid Bay, Hants County	Mineral sands	Drilling, mineralogical studies	Ongoing
Martin Roche/Hansone Limited	Avon River, Hants County	Mineral sands	Drilling, mineralogical studies	Ongoing
NAR Resources Limited	Shubenacadie River, Hants County	Mineral sands	Drilling, geochemical sampling	Ongoing

Table 5. continued.

COMPANY/INDIVIDUAL	LOCATION	COMMODITY	PROGRAM	STATUS
Robert MacDonald	Lochside, Richmond County	Barite	Diamond-drilling	-
Pasminco Resources Canada Company	Gays River area, Halifax County	Base metals	-	-
Statia Terminals Canada Limited	Port Richmond, Richmond County	Salt (underground storage)	Review of previous work	Ongoing
Strikezone Minerals (Canada) Limited	Lake Charlotte, Halifax County	Gold	Geological mapping, prospecting geochemical sampling	Ongoing
Thomas Baillie	Miller Lake	Gold	Bulk sampling	Ongoing
Tom Faulkner/Dennis Forgeron	Oceanview, Cape Breton County	Base metals, gold	Prospecting, lithogeochemical sampling, trenching, ground geophysics	-
True Metallic Explorations Inc.	Upper Falmouth, Hants County	Gold	Diamond-drilling	Ongoing
Votix Corporation Limited	Middle Stewiacke, Colchester County	Barite	Rock sampling	-

Additional trenching and diamond-drilling were also carried out during the year on the company's Lochaber Lake property, which is host to a low-grade sedimentary copper deposit with reserves of 2.4 million tons grading 0.33% Cu.

Pasminco Resources Canada Company initiated a preliminary evaluation of Pb-Zn potential in the Lower Carboniferous Windsor Group carbonates of several properties in the general vicinity of the company's Gays River Pb-Zn deposit.

Geosearch completed additional work in the Walton-Cheverie area, Hants County, including prospecting, soil geochemical sampling, and ground geophysical surveys. The company is focusing on the potential for new discoveries of base metals and barite west of the former Walton Mine.

Mr. Tom Faulkner and Mr. Dennis Forgeron initiated an exploration program for base and precious metals in the Oceanview area, Cape Breton County. Work on the property included prospecting, lithogeochemical sampling, trenching and ground geophysical surveys.

Gold

Exploration for gold also continued at approximately the same level of activity as in 1999. The lower Paleozoic Meguma Group of southern mainland Nova Scotia continued to be a focus for gold exploration in Nova Scotia.

Newfoundland Goldbar Resources Incorporated completed an exploration drilling program on the former Crown Mine gold property at Dufferin Mines, Halifax County, in mid-1999. The company continued a detailed evaluation of the property in 2000, and subsequently made a decision to proceed with an underground mining operation. The company's wholly owned subsidiary, Dufferin Resources Incorporated, entered into agreement with EnviroGold Technologies in September 2000 and mining operations were started on the property in mid-November.

True Metallic Explorations Incorporated continued a detailed evaluation of the paleoplacer potential for gold associated with clastic sedimentary rocks of the Lower Carboniferous Horton Group near Castle Frederick, Hants County. The company completed a preliminary drilling program on the property during the fall.

Strikezone Minerals (Canada) Limited, in an option agreement with Ellsin Resources Incorporated, continued a detailed evaluation of the Lake Charlotte gold property, Halifax County. Geological mapping, prospecting and soil geochemical sampling were carried out on property late in the year.

A number of small exploration programs were also completed on several properties throughout the Meguma Group by several individuals and private interests. Mr. Hubert Burrill conducted a vibracore drilling program to evaluate the placer potential of beach sands at Foote Cove beach near Pembroke, Yarmouth County. Mr. Lindsay Allen carried out prospecting and trenching to evaluate the gold potential in the immediate vicinity of the old mine workings at Mill Village in Queens County. Mr. Thomas Baillie continued an evaluation of the Miller Lake gold property in Guysborough County during the year, including completion of a bulk sample test of stock-piled material from the old workings. Mr. Joseph Collier carried out prospecting and rock geochemical sampling for gold in both the Isaacs Harbour area, Guysborough County, and in the South Branch area, Colchester County.

Other

Statia Terminals Canada Limited continued a detailed evaluation of the potential for developing underground bulk hydrocarbon storage in the extensive salt deposits of the Windsor Group in the Port Richmond area near Port Hawkesbury. Recent work included a detailed review of previous geological and geophysical work completed on the property.

Testing of Shallow Seismic Reflection Technique, Cape Breton Island (NTS 11F/10, 11F/11 and 11F/14)[1]

S. E. Pullan[2], J. A. Hunter[2], R. Burns[2], M. Douma[2] and R. R. Stea

Introduction

In September and October 2000, the Geological Survey of Canada conducted shallow seismic reflection tests at 79 sites in south-central Cape Breton Island (Fig. 1). The seismic tests were carried out to provide estimates of the depth to bedrock and to determine whether this method could be used to find and outline areas of thick overburden which might be further explored for industrial mineral resources. The sites were chosen to prove the effectiveness of this method in areas where borehole information was available, and to provide information in areas where borehole control is lacking.

This work comprises one component of a federal-provincial Targeted Geoscience Initiative (TGI) project aimed at stimulating resource development in Cape Breton Island. This project will improve the geoscience knowledge base relating to both the Carboniferous bedrock and the overlying Mesozoic and Cenozoic sediments in the area.

Shallow Seismic Reflection Method

Land-based seismic methods are geophysical techniques that use measurements of the time taken for acoustic energy to travel from a source on the surface through the subsurface and back to a series of receivers on the ground (Fig. 2). Energy is refracted or reflected at boundaries where there is a change in acoustic impedance (the product of material density and seismic velocity). Because contrasts in acoustic impedance are generally associated with lithologic and/or stratigraphic boundaries, seismic techniques can be used to obtain subsurface structural information.

Shallow seismic reflection methods (targeting subsurface structure within a couple of hundred metres of the ground surface) depend on the detection of high-frequency energy reflected from shallow velocity discontinuities. The ability of a particular site to transmit high-frequency energy is a major factor in determining the quality and the ultimate resolution of a shallow reflection survey. Data quality and resolution are critically dependent on the surface conditions, with the best results usually associated with fine-grained, water-saturated surface materials, and the poorest results with coarse-grained, dry surface sediments.

An overview of the application of land-based seismic methods to delineating the structure of unconsolidated sediments and the underlying bedrock surface can be found in Pullan and Hunter (1999).

The seismic reflection testing program discussed in this paper was designed to evaluate the quality of reflected energy (frequency and signal strength) that could be obtained in the area, to determine the depths from which reflection signals could be recorded, and to obtain an estimate of the depth to bedrock at each site. As well, these data will be a factor in determining appropriate sites or areas for future drilling programs, and in establishing recording parameters (e.g. source, source-receiver geometry, recording timescale) and potential survey lines for follow-up production CMP (common midpoint) profiling.

Data Acquisition

At each test site, data were acquired using an array of 24 geophones (Mark Products 50 Hz in marsh cases) at 5 m spacings (active spread length = 115 m; Fig. 3), generally deployed alongside roads. Wherever possible the geophones were planted in the bottom of ditches in order to improve the high-frequency response resulting from coupling to water-saturated sediments. The energy source was an in-hole "Buffalo gun" (Pullan and MacAulay, 1987), which fires a 12-gauge blank charge into the ground from 1 m below surface in a narrow-diameter, drilled hole (tamped with water). The data

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[1] A contribution to the Targeted Geoscience Initiative (TGI) project: Geological Mapping for Mineral Development in South-central Cape Breton Island; Project Leader Peter Giles, Geological Survey of Canada (Atlantic)

[2] Terrain Sciences Division, Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario K1A 0E8

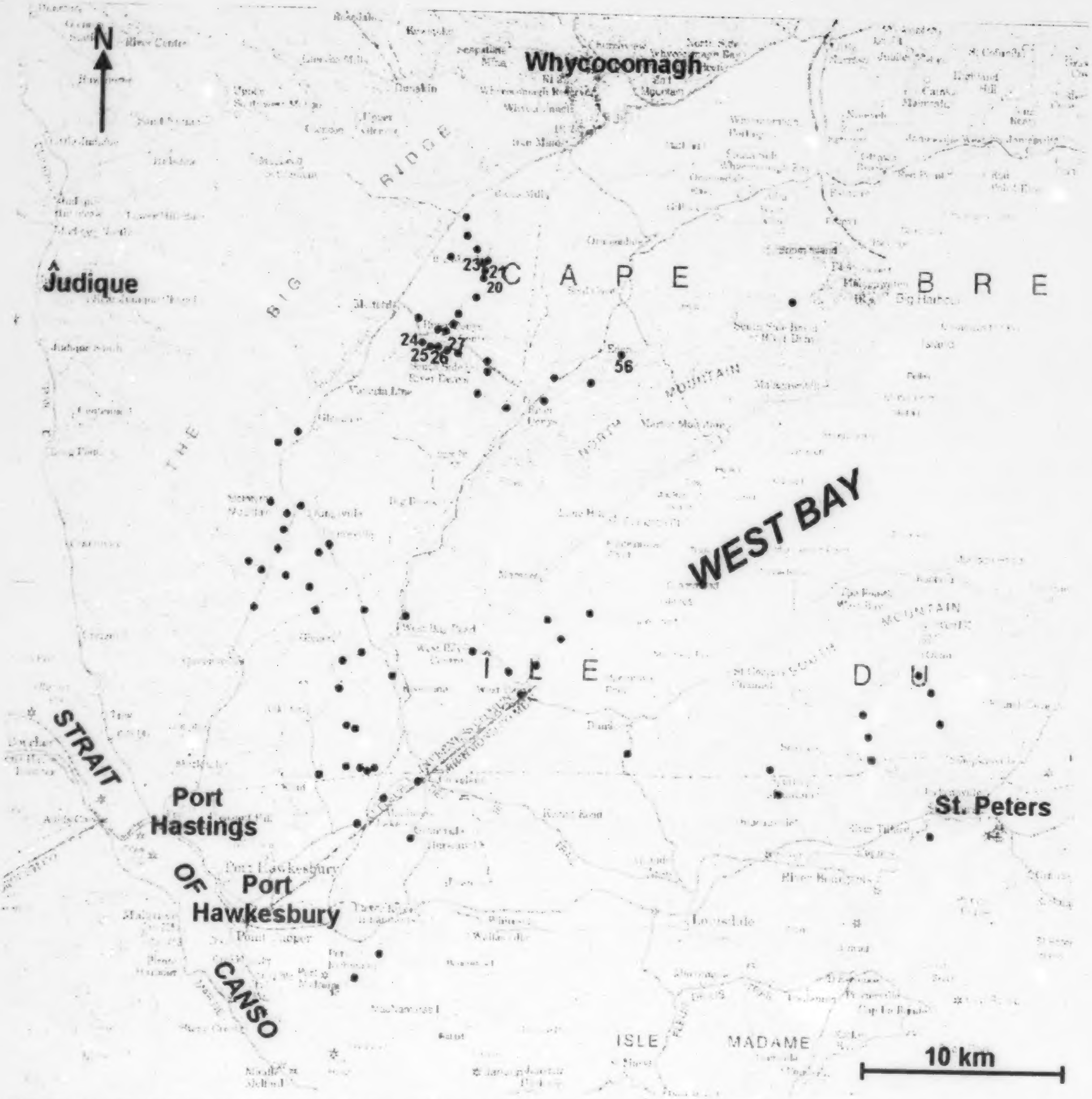

N
Whycocomagh
Judique
THE BIG RIDGE
C A P E B R E
23
21
20
24
27
25
26
56
NORTH MOUNTAIN
WEST BAY
Î L E D U
SOUTH MOUNTAIN
STRAIT OF CANSO
Port Hastings
Port Hawkesbury
St. Peters
ISLE MADAME
10 km

Figure 1. Map showing the seismic test site locations (dots) in southern Cape Breton Island (base is 1:250 000 scale topographic map NTS 11F). Data from the numbered sites are discussed in this preliminary report.

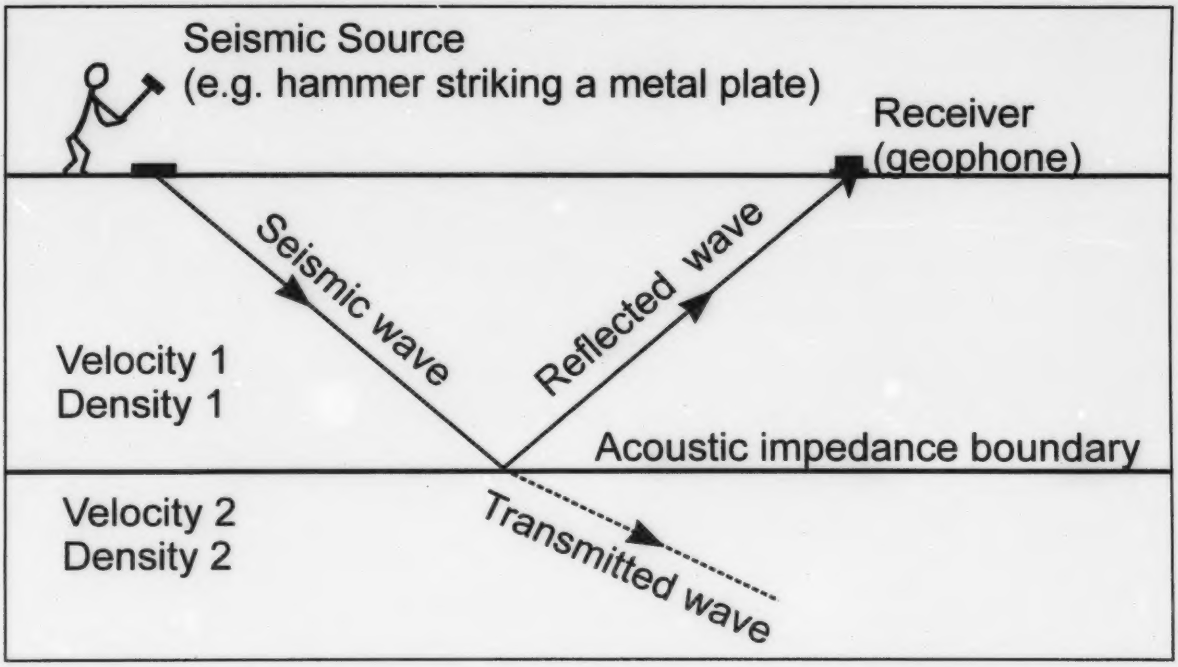

Seismic Source
(e.g. hammer striking a metal plate)
Receiver
(geophone)
Seismic wave
Reflected wave
Velocity 1
Density 1
Acoustic impedance boundary
Velocity 2
Density 2
Transmitted wave

Figure 2. Schematic illustration of the basic premise of seismic reflection methods (from Pullan and Hunter, 1999). Seismic energy produced on the ground surface travels from the source down to an acoustic impedance boundary where it is partially transmitted and partially reflected back towards the surface. The resulting ground motion at the surface is recorded by a receiver (geophone) as a function of time.

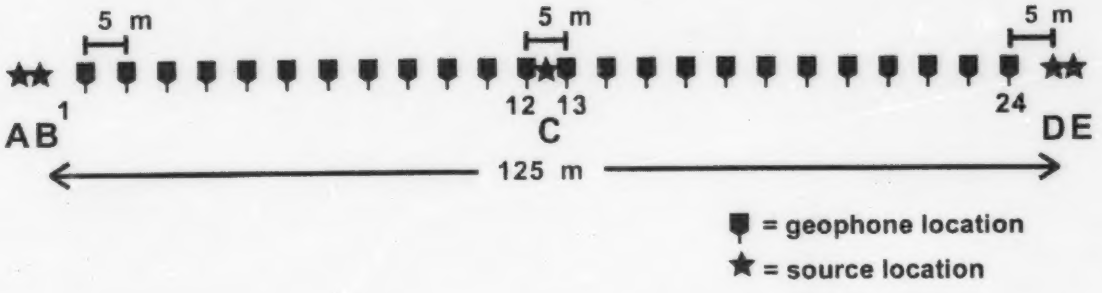

5 m
5 m
5 m
1
12 13
24
AB
C
DE
125 m
= geophone location
= source location

Figure 3. Diagram of geophone array deployment and shot locations for the acquisition of the test site data. The geophone spread consists of 24 receivers (geophones) spaced 5 m apart. Data were recorded for shots located in the centre of the geophone spread and at 5 and 7.5 m off each end of the array. (Note: at some sites additional records were recorded from shots at 47.5 and 50 m off the end of the array).

were recorded on a Geometrics Strataview RS-48 engineering seismograph, for shots fired at the midpoint of the array, and at 5 m, and 7.5 m off each end of the array (Fig. 3). At some sites, additional records were acquired with shots at 47.5 m and 50 m off the end of the array. Example suites of field records for both a shallow bedrock (bedrock refraction) site and a deeper bedrock site (bedrock reflection) are shown in Figure 4.

Results

The data collected during this testing survey are analyzed as follows:

(1) Refraction analysis of first arrival times to estimate near-surface velocity structure. In cases where refractions from the bedrock surface are observed, the first arrivals are used to estimate depth to bedrock.
(2) High-pass digital bandpass filtering of records to attempt to reduce groundroll and enhance reflection events.
(3) For sites where reflections from the bedrock surface and possibly intra-overburden horizons are evident, a low-fold, common-midpoint (CMP) seismic section is produced.

Refraction Analyses

Seismic refraction methods involve the measurement of the time of first arrival of seismic energy at a series of source-receiver separations. As the source-receiver separations increase, energy that has been critically refracted from deeper (and necessarily higher-velocity) horizons overtakes the shallower refractions and becomes the first arrival. The arrival times and source-receiver distances are used to determine layer velocities and depths to the refracting horizons. Velocity contrasts must also be large for an interface to be definitively identified in a layered-model refraction analysis.

At many test sites, bedrock was within 20-25 m of the ground surface and could be identified by high-velocity refraction arrivals. An example is shown in Figure 5 (Site 56). The upper panel of this figure is a plot of the front end (0-50 ms) of the five records obtained at the site; the central panel shows the picked first arrival times on a time-distance plot; and the lower panel shows the resultant layer velocities and depth interpretations for a simple two-layer model. The high-velocity "breakover" (change in the slope of the first arrival times) is interpreted to represent the bedrock surface (bedrock velocity = 3800 m/s) beneath 10-15 m of unconsolidated sediments (1650 m/s).

The depth to bedrock has been estimated by refraction analyses at approximately one-half of the 79 test sites surveyed. At these sites, bedrock is too shallow to be observed clearly as a reflection event.

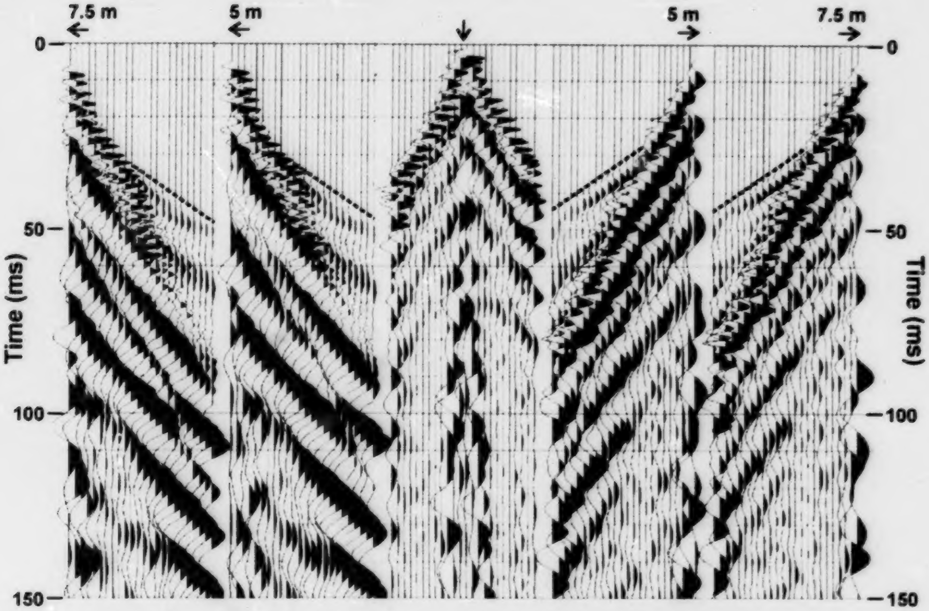
Digital Filtering

The records obtained at each site were digitally filtered in an attempt to enhance high-frequency reflection events (which appear as hyperbolic features on field records) and attenuate interfering energy such as groundroll. Figure 6 shows the record suite from Site 24 after digital filtering and application of an automatic gain control (AGC). In this case, filtering was able to enhance (sharpen) the high-amplitude reflection events seen on these records, and to essentially remove the groundroll (low-frequency, low-velocity signal observed on the near-offset traces in the raw field records). The difference in the hyperbolic moveout of the bedrock reflection observed in the records obtained from opposite ends of the spread indicates that the bedrock surface is dipping beneath the site (see below).

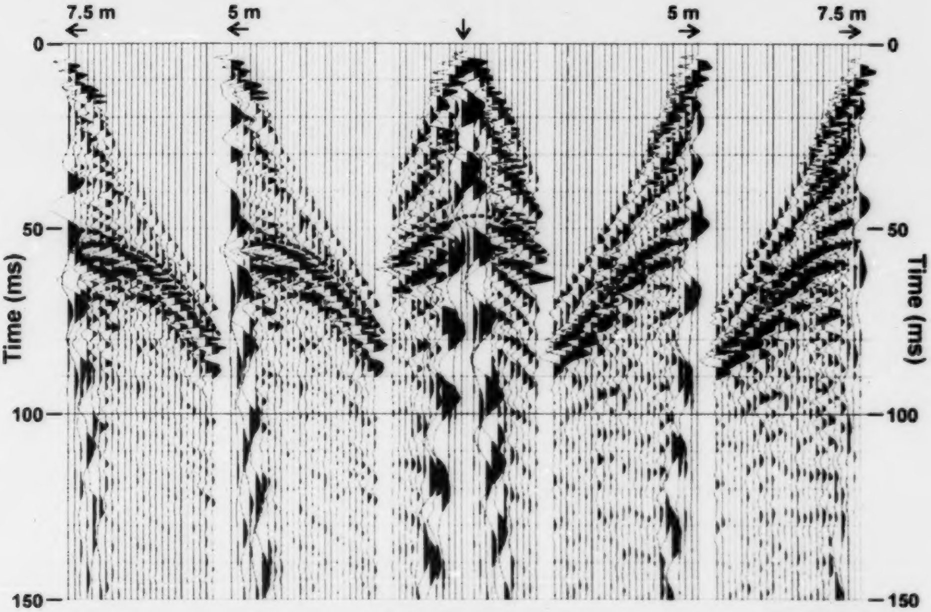
CMP Processing

A suite of records obtained with the test spread source-receiver geometry can be utilized to produce a low-fold, common-midpoint (CMP) seismic section over a limited subsurface area, and where the signal-to-noise ratio is good this can be a very effective means of providing a reconnaissance assessment of the subsurface structure (e.g. Pullan *et al.*, 1995). Processing includes digital filtering, muting of groundroll and refraction first arrivals, sorting into CMP gathers, velocity analyses, normal moveout corrections, and final stack (1-2 fold). Figure 6 shows the raw and filtered field files obtained at Site 24, along with the resulting low-fold CMP section that was produced from these data. The section shows a high-amplitude reflection that dips steeply to the east from ~40 m in the west to ~60 m depth at the east end of the section (depths are calculated using the stacking velocities). Above this reflection are lower amplitude events which dip less steeply; at 45 m depth there is an event which can be seen to pinch out against the high-amplitude reflection to the west.

A composite of four sections along a 1.5 km east-west line in the River Denys area is shown in Figure 7. It outlines a >100 m deep buried valley that is on the order of 1-1.5 km wide. Site 25 shows the deepest structure with a reflection dipping to the east at 80-110 m depth. Below this eastward-dipping reflection are indications of deeper events dipping to the west. It is not known whether these represent overburden sediments or structure within the bedrock.



Site 56: Raw field records, showing bedrock refraction.



Site 26: Raw field records, showing high-frequency reflections to an estimated depth of ~55 m.

Figure 4. Two example suites of raw field files. The source-receiver geometry for each panel of five records is shown in Figure 3, and the source offsets and direction are indicated above each record. No automatic gain control has been applied, but plots are trace-normalized. The upper panel shows the records obtained at Site 56 where a clear refraction "breakover" to higher velocities (bedrock) is observed (dashed line). The lower panel shows the records obtained at Site 26 where high-frequency reflections can be clearly seen as hyperbolic events (dashed line). The large-amplitude reflection at ~ 55-60 ms (near-offsets) is interpreted as the bedrock surface.

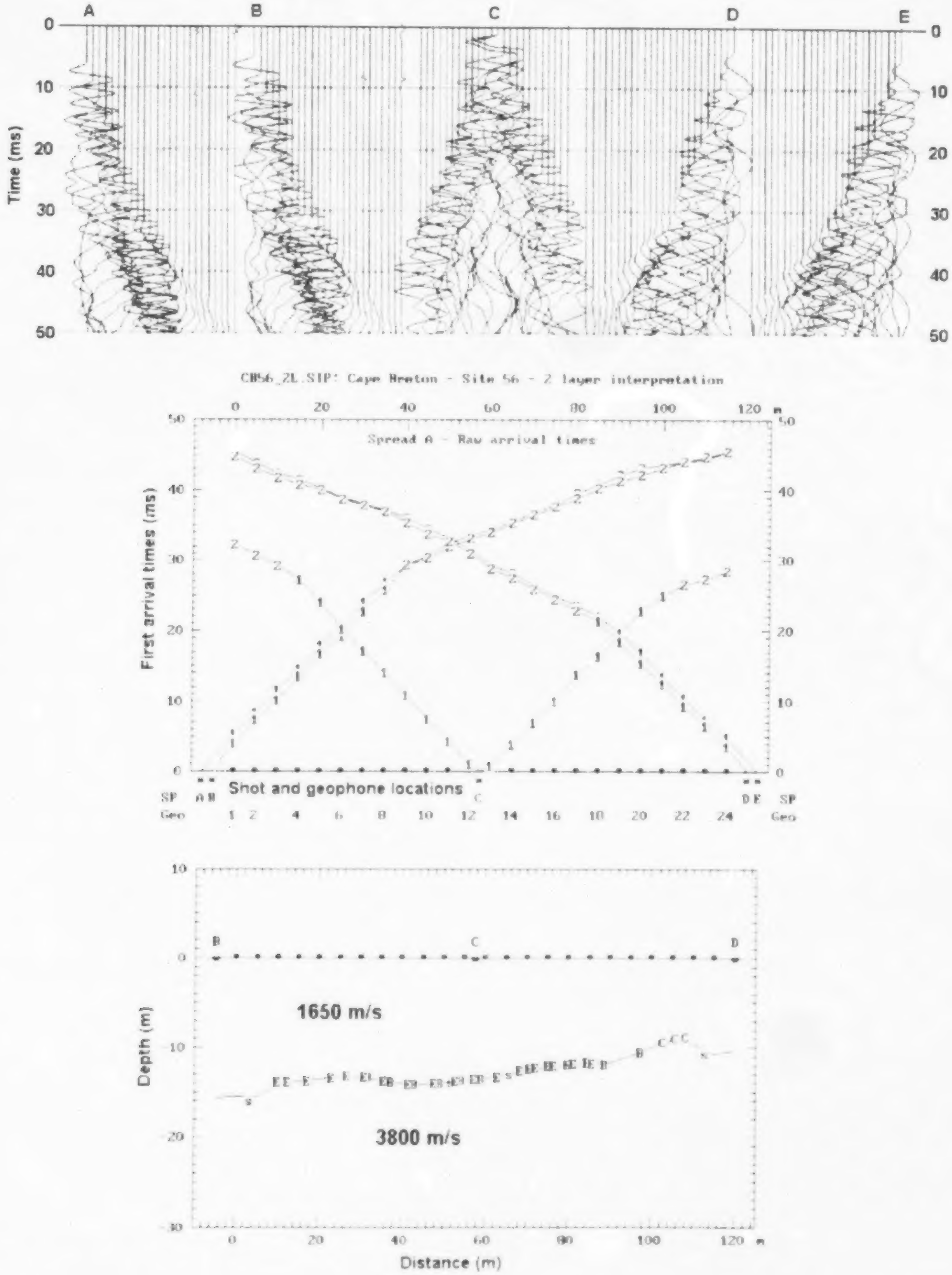


Figure 5. Refraction analysis for Site 56. The upper panel is a plot of the front end (0-50 ms) of the five records obtained at the site; the central panel shows the picked first arrival times on a time-distance plot; and the lower panel shows the resultant layer velocities and depth interpretations.

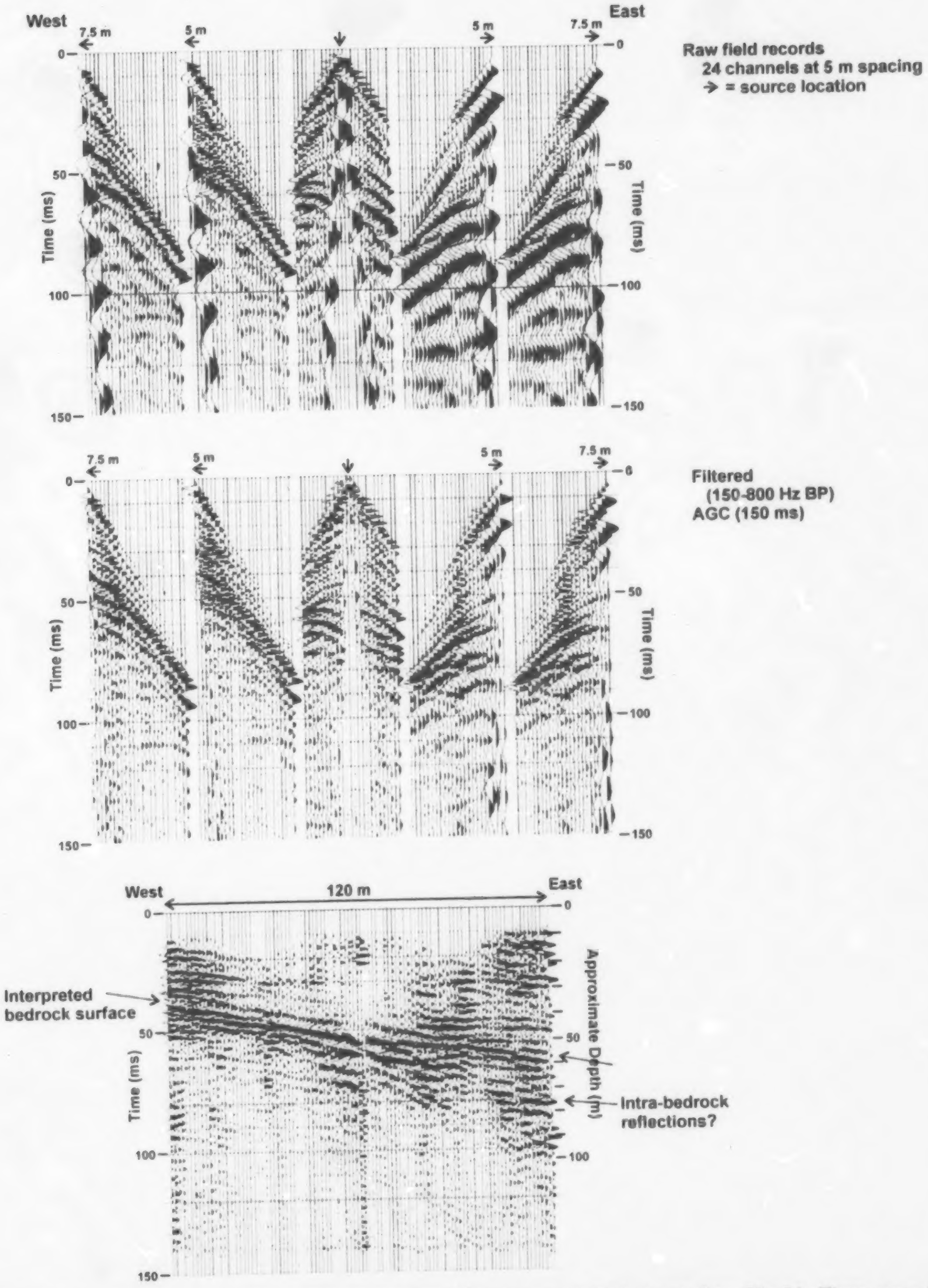


Figure 6. An example of the raw (upper panel) and filtered (centre panel) field records from Site 24. These records have been processed to produce the 96-trace seismic reflection section (1-2 fold) shown in the lower panel. This section shows the subsurface structure beneath the geophone spread used to acquire the test spread data.

Figure 8 shows three north-south sections at Big Marsh, approximately 4 km northeast of Figure 7. These sections outline another buried valley which again reaches depths of >100 m. Site 23 shows steeply dipping events which are interpreted as diffractions from a bedrock high (fault?) to the north (a test site only 250 m to the north indicated very shallow bedrock).

Drilling in the River Denys buried valley has recently been completed, with boreholes drilled at test spread sites 23 (Fig. 8) and 25 (Fig. 7). Cores at both sites reveal that the valley is filled with massive brown, Quaternary silty clay (50-70 m thick at site 23) overlain by <20 m of till and coarse gravel. At site 25, drilling was halted due to a pressurized artesian aquifer underlying the surface till at 31 m. This contact is apparent on the seismic test spread (Fig. 7).

This preliminary analysis of some of the seismic test sites shows that seismic methods can be effectively used in this region to estimate depths to bedrock, and clearly indicates that the buried bedrock topography is rugged and complex in some areas.

References

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Pullan, S. E. and MacAulay, H. A. 1987: An in-hole shotgun source for engineering seismic surveys; Geophysics, v. 52, p. 985-996.

Pullan, S. E., Good, R. L. and Ricketts, B. D. 1995: Preliminary results from a shallow seismic reflection survey, Lower Fraser Valley hydrogeology project, British Columbia; *in* Current Research 1995-A; Geological Survey of Canada, p. 11-18.

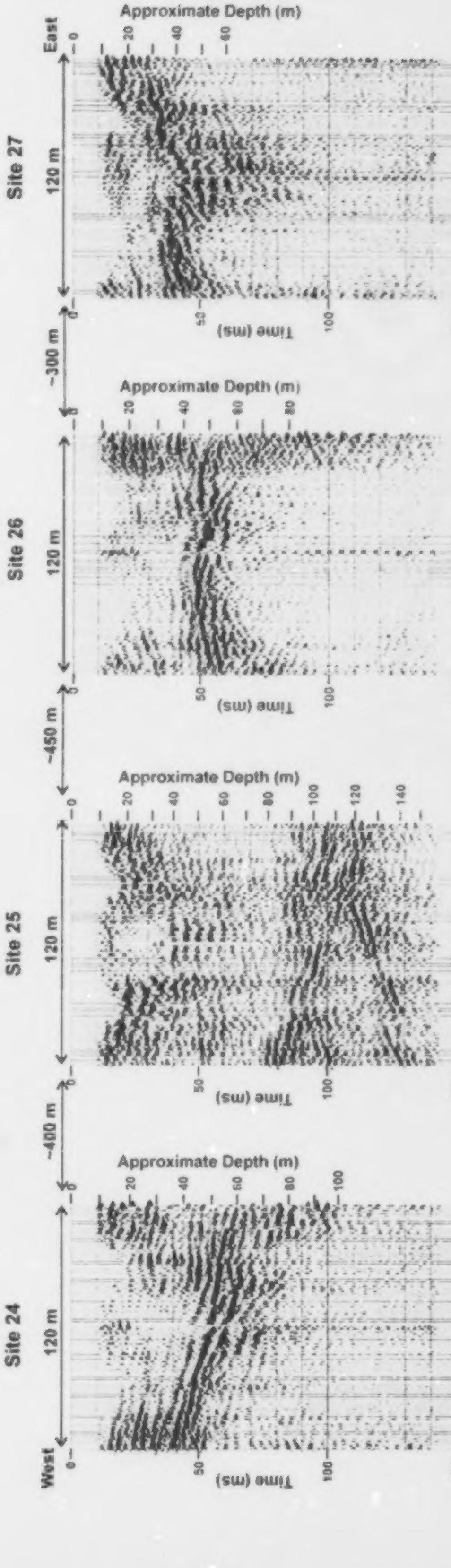

Figure 7. Four east-west sections across a >100 m deep buried valley in the River Denys area. The bedrock surface is interpreted as the high-amplitude event that dips steeply to the east at Site 24 and rises to ~30 m below ground surface at the east end of Site 27. The deep westward dipping events at Site 25 may represent overburden sediments or structure within the bedrock.

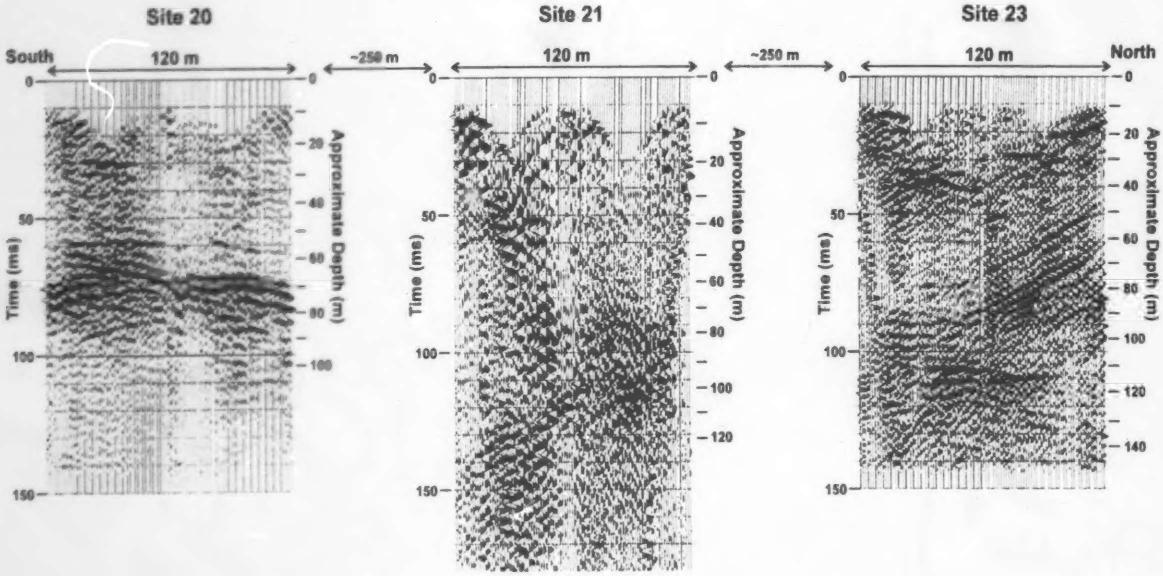

Figure 8. Three north-south sections at Big Marsh (~4 km northeast of Fig. 7). These sections outline part of another buried valley >100 m deep. The dipping events observed at Site 23 are interpreted to be diffractions from a bedrock high (fault?) immediately to the north.

Geology of the Cape Porcupine Complex (NTS 11F/11), Guysborough County, Nova Scotia[1]

C. E. White, S. M. Barr[2], J. W. F. Ketchum[3] and M. Ethier[2]

Introduction

Detailed mapping in the Cape Porcupine area of northern mainland Nova Scotia (NTS sheet 11F/11; Fig. 1) was begun in the summer of 2000. This project follows up on regional mapping done by White and Barr (1998a, b) in the Guysborough-Mulgrave-L'Ardoise area, as well as earlier mapping by Fletcher (1881, 1884), Ferguson (1946) and Ferguson and Weeks (1950) in the Strait of Canso area.

Cape Porcupine, a prominent hill adjacent to the Canso Causeway, consists of varied igneous and metamorphic rocks termed the Cape Porcupine Complex by White and Barr (1998a, b). The Cape Porcupine Complex holds a strategic position in the configuration of tectonostratigraphic terranes in the northern Appalachian orogen (Fig. 2). Hence, this study was undertaken to (1) describe the rock types that form Cape Porcupine, (2) determine their age, and (3) compare them to other "basement" rocks in northern mainland Nova Scotia and adjacent parts of Cape Breton Island. This paper provides an overview of the preliminary results of the project and outlines additional work planned to resolve some remaining geological problems.

Map Units

Introduction

Fletcher (1881, 1884) published an extensive description of the geology at Cape Porcupine. He divided the hill into a "central slate series" surrounded by "syenite" and "felsite", unconformably overlain by Devonian sedimentary rocks. The area was remapped by Ferguson (1946) and Ferguson and Weeks (1950). They subdivided the slate series and felsite into an older unit of andesite, chlorite schist, rhyolite and felsite, intruded by younger granite and alaskite, and overlain by Carboniferous sedimentary rocks of the Horton Group. As a result of quarrying from 1952-55 at Cape Porcupine for the construction of the Canso Causeway, several theses were completed on the area by students from St. Francis Xavier and Dalhousie universities, and the Massachusetts Institute of Technology (e.g. Breau, 1954; Hilton, 1954; Gillis, 1956; Rowley, 1956; Power, 1957). These studies concentrated on drill core descriptions and petrographic analyses but did not significantly change the geological map of Ferguson (1946).

Quarry operations continue at the present time, and provide excellent exposure of the varied igneous and metamorphic rocks of the Cape Porcupine Complex. Rocks of the complex are now in faulted contact on the north, east, and west with conglomerate, sandstone and slate of the Lower Carboniferous Clam Harbour River Formation (Fig. 3). However, the southern margin of the hill appears to preserve an unconformable relationship between the complex and the Clam Harbour River Formation, as indicated by the presence of a basal conglomerate that contains abundant clasts derived from the complex. As a result of our mapping and petrological studies, the Cape Porcupine Complex is divided into five map units (Fig. 3), as described below.

Metasedimentary Unit

The main body of metasedimentary rocks occupies the central area of the Cape Porcupine Complex, and is mainly fault-bounded (Fig. 3). The contact with the western granitoid unit appears to be a brittle thrust fault dipping to the west, with the granitoid rocks thrust over the metasedimentary rocks. On the east, the metasedimentary unit is in contact with metavolcanic and granitoid rocks along a vertical fault. The metasedimentary unit consists mainly of grey to black, fine-grained and strongly foliated metasiltstone with well-developed stretching lineation (see Structure and Metamorphism section). Locally the metasiltstone contains thin (<0.5 mm thick), light grey, fine-grained

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[1] Project funded by Nova Scotia Department of Natural Resources and a Natural Sciences and Engineering Research Council research grant to S. M. Barr

[2] Department of Geology, Acadia University, Wolfville, Nova Scotia B0P 1X0

[3] Royal Ontario Museum, 100 Queens Park, Toronto, Ontario M5S 2C6

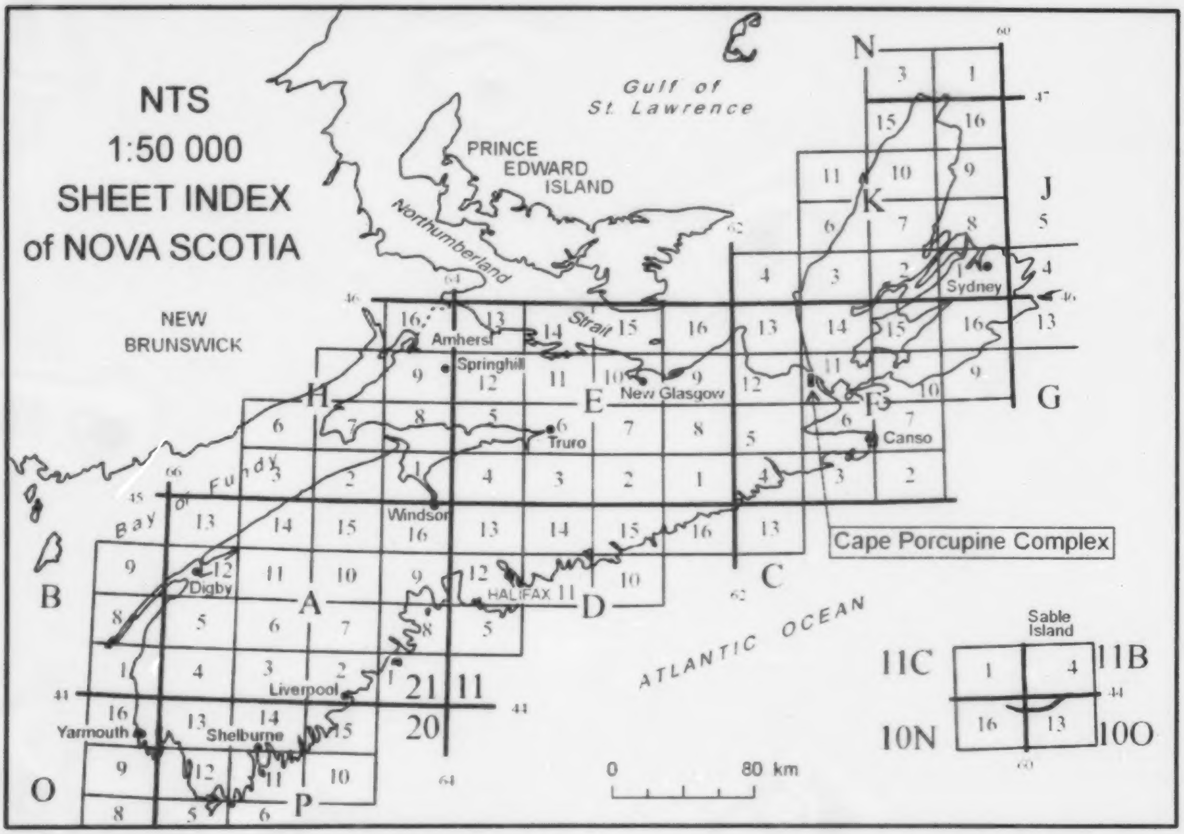

NTS
1:50 000
SHEET INDEX
of NOVA SCOTIA
NEW BRUNSWICK
PRINCE EDWARD ISLAND
Gulf of St. Lawrence
Northumberland Strait
Bay of Fundy
ATLANTIC OCEAN
Amherst
Springhill
New Glasgow
Truro
Windsor
HALIFAX
Digby
Liverpool
Yarmouth
Shelburne
Sydney
Canso
Cape Porcupine Complex
Sable Island
11C
11B
10N
10O
0
80 km

Figure 1. National Topographic System (NTS) index map of Nova Scotia showing location of the Cape Porcupine Complex.

metasandstone lenses. Rare quartzite occurs in laterally discontinuous layers, 1-2 m in thickness, in the metasiltstone. The quartzite is light to dark grey, fine-grained, heavily fractured and featureless. Along the western contact with the granitoid rocks the metasiltstone locally contains mappable metavolcanic lenses (Fig. 3).

Most of the metasiltstone is strongly deformed and recrystallized so that original sedimentary structures have been obliterated. This evidence for mylonitization suggests that the rock is more properly termed a phyllonite. Although this unit has been interpreted to be intruded by granite (e.g. Ferguson, 1946), no evidence for such a relationship, such as contact metamorphism, was observed during the present study.

Metavolcanic Unit

The metavolcanic unit outcrops in the eastern part of the complex and is mainly fault-bounded (Fig. 3). It consists dominantly of white-weathered, grey to dark grey, crystal to crystal-lithic rhyolitic tuff. Crystals are small (<3 mm maximum diameter) and include rounded embayed quartz, subhedral anorthoclase, and subhedral plagioclase set in a fine-grained to aphanitic, locally spherulitic, groundmass of microcrystalline quartz and feldspar. Lithic clasts are generally small (<1 cm in diameter), flattened parallel to foliation, and typically consist of rhyolitic tuff. Clasts of andesitic tuff and metasiltstone are rare. Using the relative modal abundances of crystals, the tuffs range from alkali rhyolite to rhyolite (Fig. 4). As in the metasedimentary unit, the tuff is strongly foliated and the lineation is defined by elongate quartz crystals and lithic clasts. Volcanic layering is difficult to recognize because of the strong foliation and, where present, layering has been transposed parallel to foliation. The original relationship of the metavolcanic unit to the metasedimentary unit is unknown, but based on the presence of rare metasiltsone clasts in the metavolcanic rocks and metavolcanic lenses in the metasiltstone unit, they may be interlayered.

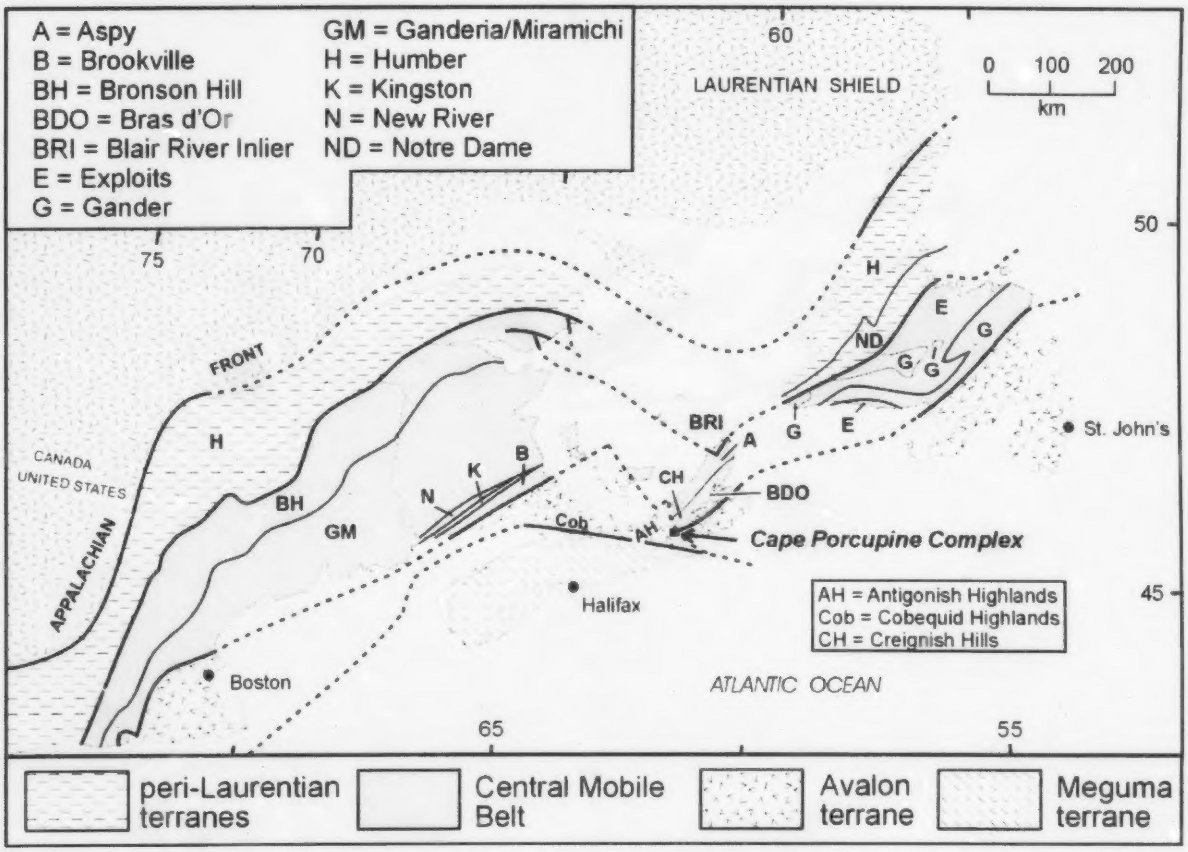

A = Aspy
B = Brookville
BH = Bronson Hill
BDO = Bras d'Or
BRI = Blair River Inlier
E = Exploits
G = Gander
GM = Ganderia/Miramichi
H = Humber
K = Kingston
N = New River
ND = Notre Dame
LAURENTIAN SHIELD
0 100 200 km
60
50
75
70
65
55
45
FRONT
APPALACHIAN
CANADA
UNITED STATES
H
BH
GM
N
K
B
Cob
AH
CH
BRI
A
G
E
ND
BDO
Cape Porcupine Complex
St. John's
Halifax
Boston
ATLANTIC OCEAN
AH = Antigonish Highlands
Cob = Cobequid Highlands
CH = Creignish Hills
peri-Laurentian terranes
Central Mobile Belt
Avalon terrane
Meguma terrane

Figure 2. Location of the Cape Porcupine Complex in relation to the tectonostratigraphic subdivisions in the northern Appalachian orogen (modified from Barr *et al.*, 1998).

Granitoid Units

Granitoid rocks form both the western and eastern parts of the Cape Porcupine Complex (Fig. 3). Based on the presence of similar alkali-feldspar granite in both areas, the western and eastern units are inferred to be co-magmatic, although they are everywhere separated by the fault-bounded metasedimentary and metavolcanic units. In both areas, the granitoid rocks display variably cataclastic textures, but mylonitic granite was observed only in the eastern unit.

Western Granitoid Unit

The western granitoid unit consists mainly of pink to pink and grey granite, mixed with abundant enclaves of more mafic plutonic rocks and metavolcanic rocks of andesitic to rhyolitic composition. The granite appears to vary gradationally in composition from monzogranite to syenogranite, and alkali-feldspar granite (Fig. 4). Texture also varies from coarse-grained equigranular to medium-grained porphyritic with phenocrysts of quartz and plagioclase up to 1 cm in length. Interstitial granophyre generally is present in alkali-feldspar granite and syenogranite samples. Mafic minerals may have originally been hornblende and biotite, but they have been entirely altered to chlorite and iron oxides. Accessory minerals include zircon, titanite, apatite and magnetite.

Plutonic enclaves in the granitic rocks are of leucodiorite/quartz diorite and tonalite composition. The leucodiorite/quartz diorite is white to light grey, medium- to coarse-grained and inequigranular, and consists of a framework of subhedral plagioclase grains and interstitial mafic minerals, locally forming up to 30% of the rock. The mafic minerals include amphibole that has been partially to entirely replaced by chlorite, and possibly clinopyroxene, now entirely replaced by chlorite and iron oxides. Minor interstitial quartz and rare perthitic alkali feldspar are also present. Accessory minerals include abundant euhedral apatite, as well as

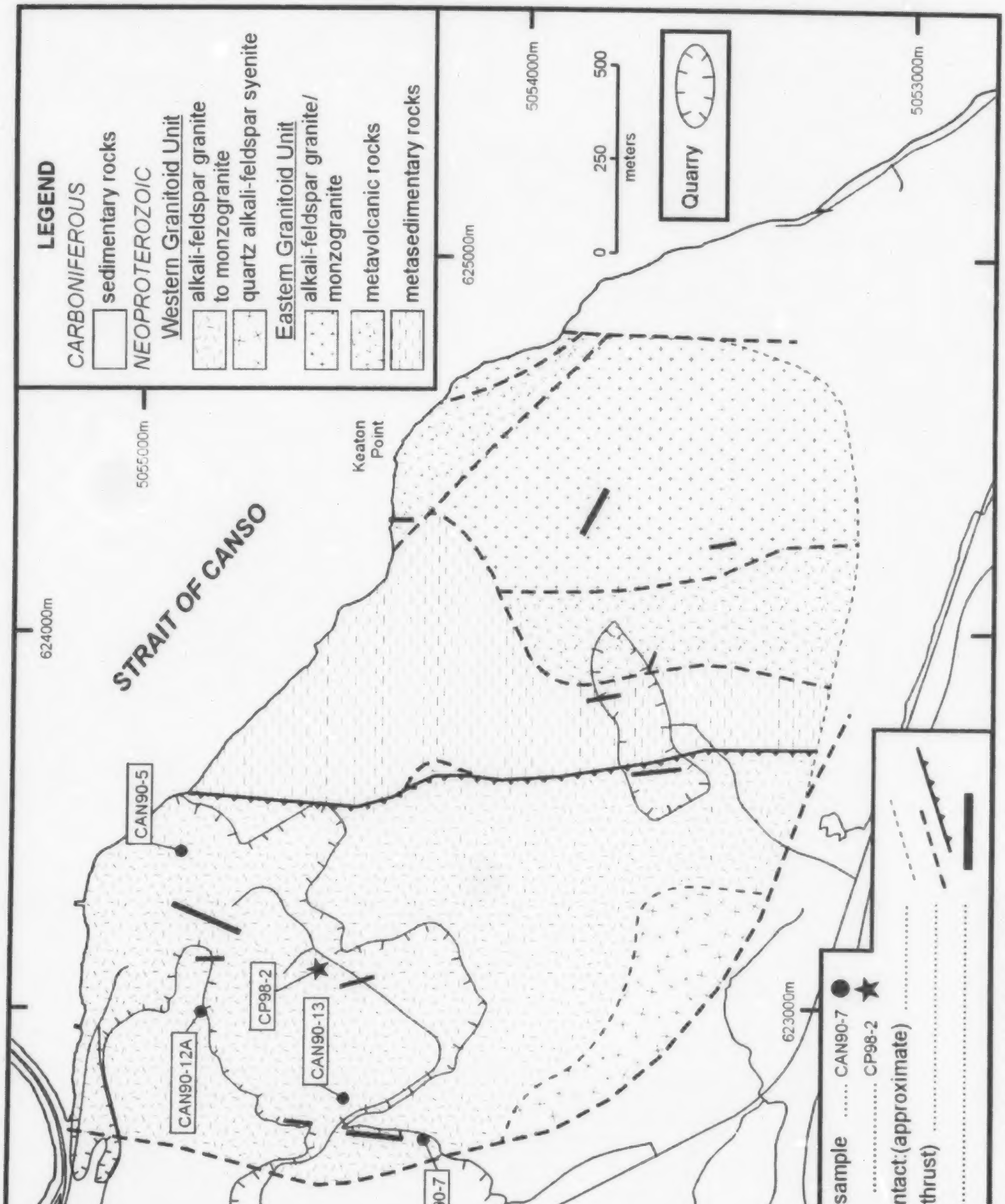

LEGEND
CARBONIFEROUS
sedimentary rocks
NEOPROTEROZOIC
Western Granitoid Unit
alkali-feldspar granite to monzogranite
quartz alkali-feldspar syenite
Eastern Granitoid Unit
alkali-feldspar granite/ monzogranite
metavolcanic rocks
metasedimentary rocks
0
250
500
meters
Quarry
STRAIT OF CANSO
Keaton Point
Morrisons Lake
624000m
625000m
623000m
5055000m
5054000m
5053000m
CAN90-5
CAN90-12A
CP98-2
CAN90-13
CAN90-7
Geochemical sample CAN90-7
U-Pb sample CP98-2
Geological contact:(approximate) ....
Fault: (steep, thrust) ....
Mafic dyke ....

Figure 3. Simplified geological map of the Cape Porcupine Complex.

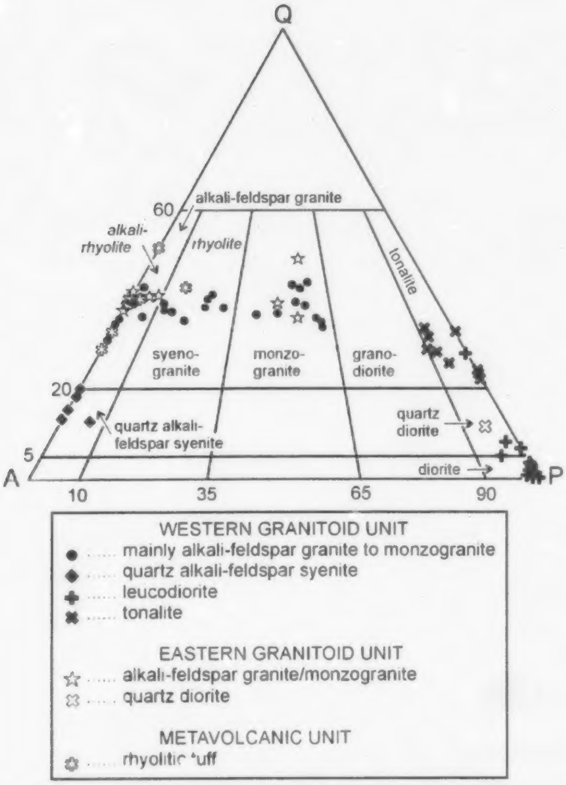


Figure 4. Ternary plot of modal quartz (Q)-plagioclase (P)-alkali feldspar (A) compositions (after Streckeisen, 1976) for samples from the granitoid and metavolcanic units in the Cape Porcupine Complex. Italicized names refer to volcanic equivalents.

zircon, titanite, and magnetite. Tonalitic enclaves in the granitic rocks are dark grey to pinkish-grey, fine- to medium-grained and equigranular, but locally contain phenocrysts of quartz and plagioclase up to 1 cm in length. They consist mainly of plagioclase laths, accompanied by up to 20% chloritized amphibole and clinopyroxene(?). Accessory minerals include apatite, titanite and magnetite.

A mappable body of quartz alkali-feldspar syenite occurs in the southwestern part of the western granitoid belt (Fig. 3). The syenite is typically red to red and grey, medium- to coarse-grained, and composed of euhedral to subhedral, coarsely perthitic alkali feldspar and interstitial quartz. Dark green euhedral amphibole, altered pyroxene(?) and secondary chlorite locally constitute up to 10% of the rock. A distinctive characteristic of this unit is the abundant interstitial magnetite (up to 9%). Titanite and apatite are additional accessory phases. The relationship of syenite to the more granitic rocks of the Cape Porcupine Complex is not known. However, both granitic and syenitic rocks contain similar perthitic alkali feldspar and tonalitic enclaves and, hence, are inferred to be of similar age.

Eastern Granitoid Unit

The eastern granitoid unit consists mainly of alkali-feldspar granite with local areas of monzogranite and quartz diorite (Fig. 4), similar to compositionally equivalent rocks in the western granitoid unit, and is assumed to be of similar age. However, the alkali-feldspar granite in the eastern granitoid belt is more deformed than in the western belt and in places discrete mylonite zones are present. The mylonitic granite zones appear to correspond to the "gneissoid" beds of Fletcher (1881). In these zones, few of the primary igneous features are preserved, but the rocks appear to have been coarse grained, with abundant quartz and alkali feldspar, and in some cases plagioclase. The mylonite contains abundant quartz ribbons and K-feldspar augen in a fine-grained quartz-feldspar groundmass.

Mafic Dykes

Mafic dykes are a minor component in all units of the Cape Porcupine Complex, as well as in the Clam Harbour River Formation (e.g. White and Barr, 1998a). They are typically 1 to 2 m wide, although the largest observed dyke is about 5 m wide, and are fine- to medium-grained with well developed chilled margins. Many of the dykes are undeformed and cut mylonitic fabrics in the host rocks. Such dykes consist dominantly of intergranular plagioclase, clinopyroxene and opaque minerals. They are likely to be Early Carboniferous in age because they occur in the Clam Harbour River Formation as well as in the older units. However, some mafic dykes in the complex are very altered, contain amphibole and/or chlorite instead of clinopyroxene, and may represent older episodes of dyke emplacement.

Clam Harbour River Formation

The Clam Harbour River Formation was assigned to the lower part of the Carboniferous Horton Group by White and Barr (1998a). In the Cape Porcupine area, the formation consists mainly of light grey to green sandstone and siltstone interlayered with grey polymictic conglomerate and minor black laminated siltstone and shale. Clasts in the conglomerate are dominantly rock types that occur in the Cape Porcupine Complex, indicating that the formation was deposited unconformably on the complex, although most of the present contacts appear to be faults (Fig. 3).

Age

To better constrain the age of the Cape Porcupine Complex, a sample of syenogranite from the western granitoid unit was collected for dating (Fig. 3). The analyzed sample consists of coarse-grained quartz in a matrix of medium-grained alkali feldspar and minor plagioclase. Analytical work was carried out at the Radiogenic Isotope Facility at the Memorial University of Newfoundland following the methods outlined in Ketchum *et al.* (1997).

The sample yielded a single population of colourless, euhedral to subhedral, doubly terminated zircon prisms (length/breadth ratio 2:1), most of which contain minor solid and fluid inclusions and cracks. The best quality grains lack inclusions and cracks but are not abundant. The sample also yielded a small quantity of turbid yellow monazite grains that were not analyzed because of their poor quality. Three abraded zircon fractions (Z1-Z3) plot as slightly discordant clusters (Fig. 5) with $^{207}Pb/^{206}Pb$ ages of 609-613 Ma (Table 1). Because the precise age of these fractions is somewhat ambiguous, a fourth fraction of best quality, strongly abraded grains was analyzed. This fraction (Z4) yielded a concordant age of 608±6 Ma. However, in considering the range of all $^{207}Pb/^{206}Pb$ ages, the ±6 million year uncertainty appears to be somewhat high for the sample age. We instead prefer to cite an age of 610±3 Ma for the Cape Porcupine granite, which spans the range of $^{207}Pb/^{206}Pb$ ages of all fractions.

Because petrographic features suggest that all of the granitoid rocks in the Cape Porcupine Complex are co-magmatic, it is assumed that the U-Pb age of ca. 610 Ma represents the approximate age of all the granitoid rocks in the complex. Because the contacts are faulted, this age does not constrain the ages of the metasedimentary and metavolcanic units. However, the presence of volcanic xenoliths in the granitoid units suggests that the volcanic unit may be older.

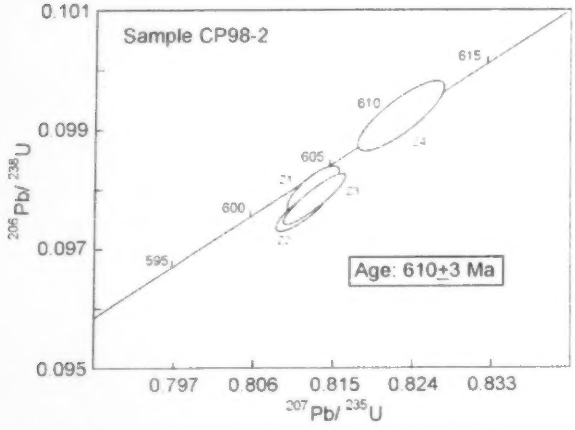


Figure 5. U-Pb concordia plot for granitoid sample from the Cape Porcupine Complex (Z1-Z4 refer to zircon populations; (Table 1).

Geochemistry

As a preliminary indication of the chemical character of the Cape Porcupine Complex, five granitic samples from the western granitoid unit (Fig. 3) were analyzed for major and selected trace elements by X-ray fluorescence at the Nova Scotia Regional Geochemical Centre, Saint Mary's University. The samples have SiO_2 contents greater than 74%, consistent with their felsic modal mineralogy and low mafic mineral content, and Zr/TiO_2 ratios like those of subalkaline rhyolite (Fig. 6a). On the Rb vs Y+Nb tectonic setting discrimination diagram, the samples plot in both the volcanic-arc and within-plate granite fields (Fig. 6b).

Additional chemical analyses are being done to investigate the petrogenesis of the granitoid units and their relationship to the metavolcanic rocks.

Structure and Metamorphism

Metasedimentary rocks in the Cape Porcupine Complex contain the mineral assemblage muscovite, chlorite, epidote and albitic plagioclase, indicative of lowermost greenschist facies metamorphism. The metasedimentary rocks display a well-developed mylonitic foliation defined by muscovite and chlorite that display uniform crystallographic orientation. The foliation strikes north-northwest with steep to shallow dips and near horizontal, north-south plunging stretching lineations (Fig. 7a). This deformation has also affected the metavolcanic rocks and some of the granitoid rocks in the eastern granitoid belt (Fig. 3). Preliminary observations suggest an overall dextral, strike-slip sense of movement. Bedding orientations in the Carboniferous sedimentary rocks are somewhat scattered but indicate upright, north-northeast plunging folds (Fig. 7b).

Much of the Cape Porcupine Complex has been overprinted by younger brittle deformation that resulted in numerous faults, breccia zones and the cataclastic textures observed in the granitoid units. Based on petrographic studies the main episode of alteration occurred during this brittle deformation. The lack of deformation and alteration in the clinopyroxene-bearing mafic dykes suggests that the alteration occurred before

Table 1. U-Pb analytical data.

		Concentration		Measured		Corrected Atomic Ratios[c]							Age (Ma)		
Fraction[a]	Weight (mg)	U (ppm)	Pb rad (ppm)[b]	Total Common Pb (pg)	206Pb/204Pb	208Pb/206Pb	206Pb/238Ub		207Pb/235U		207Pb/206Pb		206Pb/238U	207Pb/235U	207Pb/206Pb
CP98-2															
Z1 sm clr 2:1 euh (42)	0.018	394	40.4	17	2525	0.1547	0.09801	32*	0.8127	24*	0.06014	12*	603	604	609
Z2 sm clr 2:1 euh (41)	0.014	482	48.8	26	1617	0.1467	0.09764	28*	0.8114	24*	0.06027	10*	601	603	613
Z3 sm clr 2:1 euh (37)	0.018	412	42.1	16	2883	0.1535	0.09784	34*	0.8128	28*	0.06026	10*	602	604	613
Z4 sm clr euh best (40)	0.010	324	33.3	15	1346	0.1440	0.09923	48*	0.8226	40*	0.06012	18*	610	610	608

[a] All fractions were abraded following the method of Krogh (1982). Z, zircon; sm, small, euh, euhedral; clr, colourless; 2:1, length:breadth radio. Number of analyzed grains in parentheses.

[b] Total radiogenic Pb after correction or blank, common Pb, and spike.

[c] Ratios corrected for fractionation, spike, 10-15 pg laboratory blank, initial common Pb (calculated with the model of Stacey and Kramers (1975) for the age of the sample), and 0.5 pg U blank.

* Uncertainties (2 sigma) on the isotopic ratios refer to the final digits.

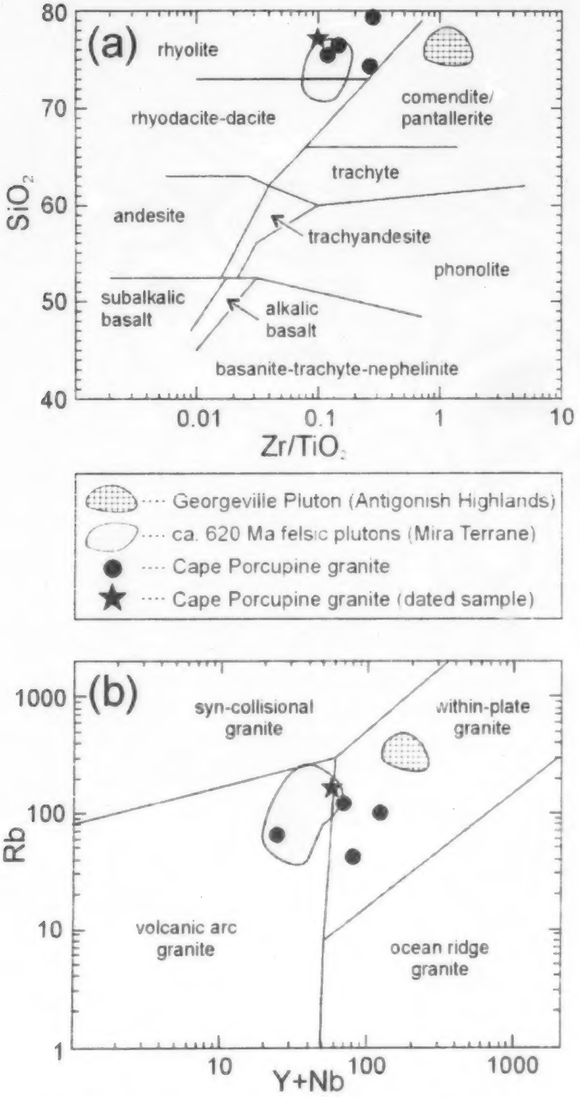


Figure 6. (a) Plot of Zr/TiO_2 against SiO_2 with fields from Winchester and Floyd (1977). (b) Tectonic setting discrimination diagram for felsic granitoid samples from the Cape Porcupine Complex. Granite fields from Pearce et al. (1984).

the early Carboniferous. However, the same clinopyroxene-bearing mafic dykes are locally offset by vertical and subhorizontal faults and breccia zones (e.g. Hilton, 1954; Rowley, 1956).

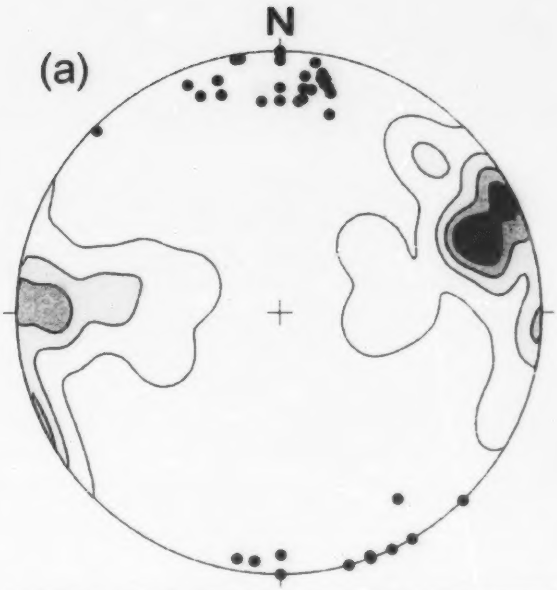
Economic Geology

Quartz-carbonate veins are common in the complex and typically contain abundant pyrite, locally associated with sphalerite and chalcopyrite. In addition, abundant pyrite with minor chalcopyrite also occurs as finely disseminated grains in granitoid and metavolcanic units. Minor malachite staining occurs along fractures in the metasedimentary unit. During quarrying operations in the 1950s, veins containing promising copper and gold leads were located but follow-up work showed them to be uneconomic (Hilton, 1954). Quartz veins containing gold were also reported to occur in the metasedimentary unit by Fletcher (1881), but were not confirmed during this study. Because of the intense alteration, low mafic mineral content, and abundant alkali feldspar, many of the granitoid rocks in the complex may have potential as a source of industrial feldspar used in glass and ceramic production. The granitic and metasedimentary rocks in the Cape Porcupine Complex are currently being exploited as a source of aggregate.

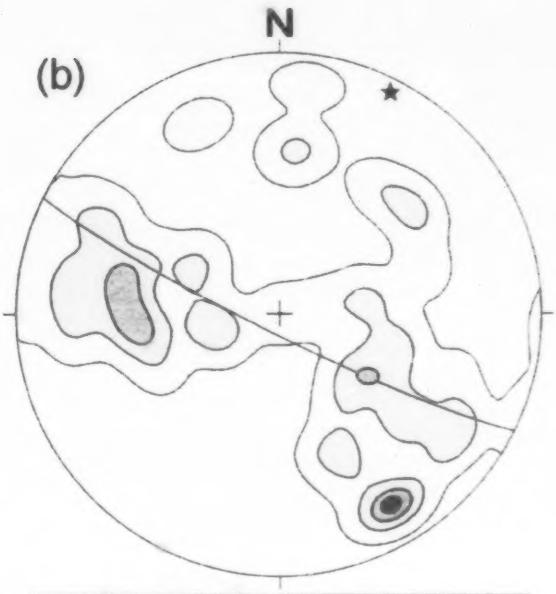
Regional Implications and Future Work

Based on the association of metasedimentary, metavolcanic and granitic rocks, Fletcher (1881, 1984), Ferguson (1946), Ferguson and Weeks (1950) and Keppie (2000) correlated the rocks at Cape Porcupine with the George River Group (Blues Brook Formation of Raeside and Barr, 1990) and associated granitic rocks exposed in the Creignish Hills in adjacent Cape Breton Island. However, in addition to clastic sedimentary and minor volcanic rocks, the Blues Brook Formation also includes marble and calc-silicate rocks that are not present in the Cape Porcupine Complex. Also, granitoid rocks in the Creignish Hills are not mineralogically or texturally similar to those in the Cape Porcupine Complex, and appear to be younger (White *et al.*, 1990; Keppie *et al.*, 2000).

Although correlation between the Cape Porcupine Complex and the Creignish Hills is supported somewhat by aeromagnetic data that suggest continuity between the two areas, the pattern is complex and disrupted by apparent NNW-trending structures (Fig. 8). The question of correlation is important for terrane interpretations (Fig. 2) because Barr and Raeside (1989) postulated the presence of a northwest-trending "Canso fault" under the Strait of Canso on the basis that geological units and terranes do not appear to correlate across the strait. The mylonitic rocks in the Cape Porcupine Complex may be the first direct evidence for the presence of the Canso fault.



Contoured poles to mylonitic foliation (n=37), contours at 1, 4, 7, and >10% per unit area.
● = stretching lineation (n=37)



Contoured poles to bedding in the Carboniferous units (n=55), contours at 1, 3, 5, and >7% per unit area.
★ = fold axis (026/06)

Figure 7. Summary of structural data from the Cape Porcupine area: (a) mylonitic fabrics; (b) Clam Harbour River Formation

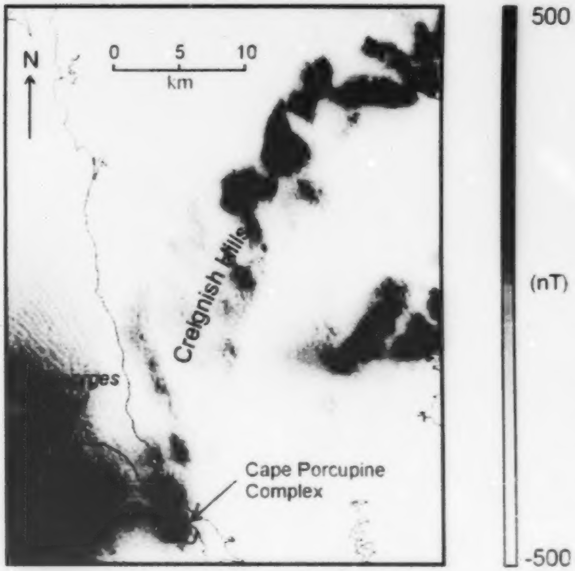


Figure 8. Grey-scale total magnetic field map of southwestern Cape Breton Island and the Strait of Canso area. Sun shading from the west at a 35° inclination. Data gridded at 100 m. Data from the Geological Survey of Canada (1997).

Units comparable in age and/or composition to those of the Cape Porcupine Complex also occur in the Mira terrane of southeastern Cape Breton Island, and in the Antigonish and Cobequid highlands of northern mainland Nova Scotia (Fig. 2). The ca. 610 Ma granite in the Cape Porcupine Complex is similar in age to some granitic units in the Mira terrane (Barr et al., 1996), and to the Georgeville Pluton in the Antigonish Highlands (Murphy et al., 1998). The analyzed samples from granite in the Cape Porcupine Complex appear similar to the more chemically evolved parts of the ca. 620 Ma calc-alkaline felsic plutons of the Mira terrane, but are chemically different from the alkalic rocks of the Georgeville Pluton (Fig. 6a, b). More detailed comparisons will be possible when a larger and more representative geochemical database has been obtained for granitoid and metavolcanic units in the Cape Porcupine Complex, and when the age of the metavolcanic unit is known.

At the present time, the relationship of the Cape Porcupine Complex to other igneous and metamorphic rocks in adjacent parts of Cape Breton Island and northern mainland Nova Scotia, and hence its terrane affiliation, remain uncertain.

Acknowledgments

We thank Peter Giles (Geological Survey of Canada, Atlantic) and Bob Boehner for many helpful discussions about the Carboniferous geology in northern mainland Nova Scotia and southern Cape Breton Island. We also thank J. Ferguson and D. Fraser of Martin Marietta Limited and P. van Zutphen of J&T van Zutphen Construction for giving us access to the quarries. Tracy Lenfesty is thanked for help in the departmental library. Comments on the manuscript by T. Goodwin were very helpful.

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Geology of the Meteghan River-Yarmouth area: a Progress Report on the Southwest Nova Scotia Mapping Project

C. E. White, R. J. Horne, P. J. Teniere[1], M. J. Jodrey[1] and M. S. King[1]

Introduction

Mapping of the bedrock geology of the Yarmouth - Meteghan River area (NTS map areas 21A/01, 21A/04, 20O/16, 20O/13), southwest Nova Scotia (Fig. 1a), was initiated during the summer of 2000. This project represents the third year of a five-year program by the Nova Scotia Department of Natural Resources aimed at producing a series of 1:50 000 scale geological maps of the Digby-Yarmouth-Shelburne area (Fig. 1b). Details of the mapping program, previous geological investigations, and methodology were summarized by White *et al.* (1999), and preliminary results of the first two years (covering NTS map areas 21A/12, 21A/05, and 21B/08) were presented by White *et al.* (1999) and Horne *et al.* (2000).

Field Relations and Map Units

Introduction

Metamorphic rock units defined in the two previous map areas to the north (NTS 21A/12, 21A/05 and 21B/08) can be traced into the Meteghan River-Yarmouth map area. They include the Cambrian to Ordovician Meguma Group, consisting of the lower Goldenville Formation and the upper Halifax Formation, and the Silurian White Rock Formation (WRF) (Fig. 2). In contrast to the map areas to the north, outcrops characteristic of the Early Devonian Torbrook Formation were not observed. Also, in contrast to the WRF in the Digby - Weymouth areas, the WRF in the Yarmouth area includes abundant volcanic rocks, and is associated with plutonic units of similar Silurian age (e.g. Brenton Pluton). The metamorphic units are intruded by several suites of mafic sills (e.g. White *et al.*, 1999; Horne *et al.*, 2000), and both the sills and their host rocks have been deformed and regionally metamorphosed to varying degrees, ranging from greenschist facies (chlorite or biotite zone) to amphibolite facies (garnet or staurolite zone).

Exposure is generally good along the coast but is limited inland due to low topographic relief and extensive glacial deposits. High-resolution second derivative aeromagnetic and digital elevation model (DEM) data (Fig. 3) were used to help define map units inland.

Goldenville Formation

The Goldenville Formation occurs in the southeastern and central parts of the map area (Fig. 2). In the southeast and the northern part of the central area, it consists of grey medium- to thick-bedded metasandstone, locally interlayered with green, cleaved metasiltstone and rare black slate, similar to the Goldenville Formation exposed to the north (e.g. Horne *et al.*, 2000). In the southern part of the central area, metamorphic grade is higher, and the metasandstone is muscovite-rich and interlayered with phyllite. Toward the stratigraphic top of the formation, the metasandstone becomes increasingly interlayered with black slate (Cheboque Point area, Fig. 2) or spotted phyllite (Cranberry Point area, Fig. 2).

A distinctive feature of the Goldenville Formation near High Head (Fig. 2) is a <1.0 km thick interval of mainly grey-green, cleaved metasiltstone which contains abundant trace fossils (Fig. 4) and small (<2 mm) magnetite grains. A similar, <200 m thick, magnetite-bearing interval occurs nearby to the south, but lacks abundant trace fossils and is locally interlayered with metasandstone. Similar rocks with similar aeromagnetic response occur in the Salmon River area (Fig. 2 and 3) and may be the folded equivalents. These magnetite-bearing rocks occur about 5 km from the stratigraphic top of the Goldenville Formation. These intervals are distinct within the Goldenville Formation and may provide useful marker horizons in this area. The high magnetite content has resulted in a relatively high aeromagnetic signature with respect to the surrounding Goldenville Formation, allowing these units to be traced inland (Fig. 2 and 3).

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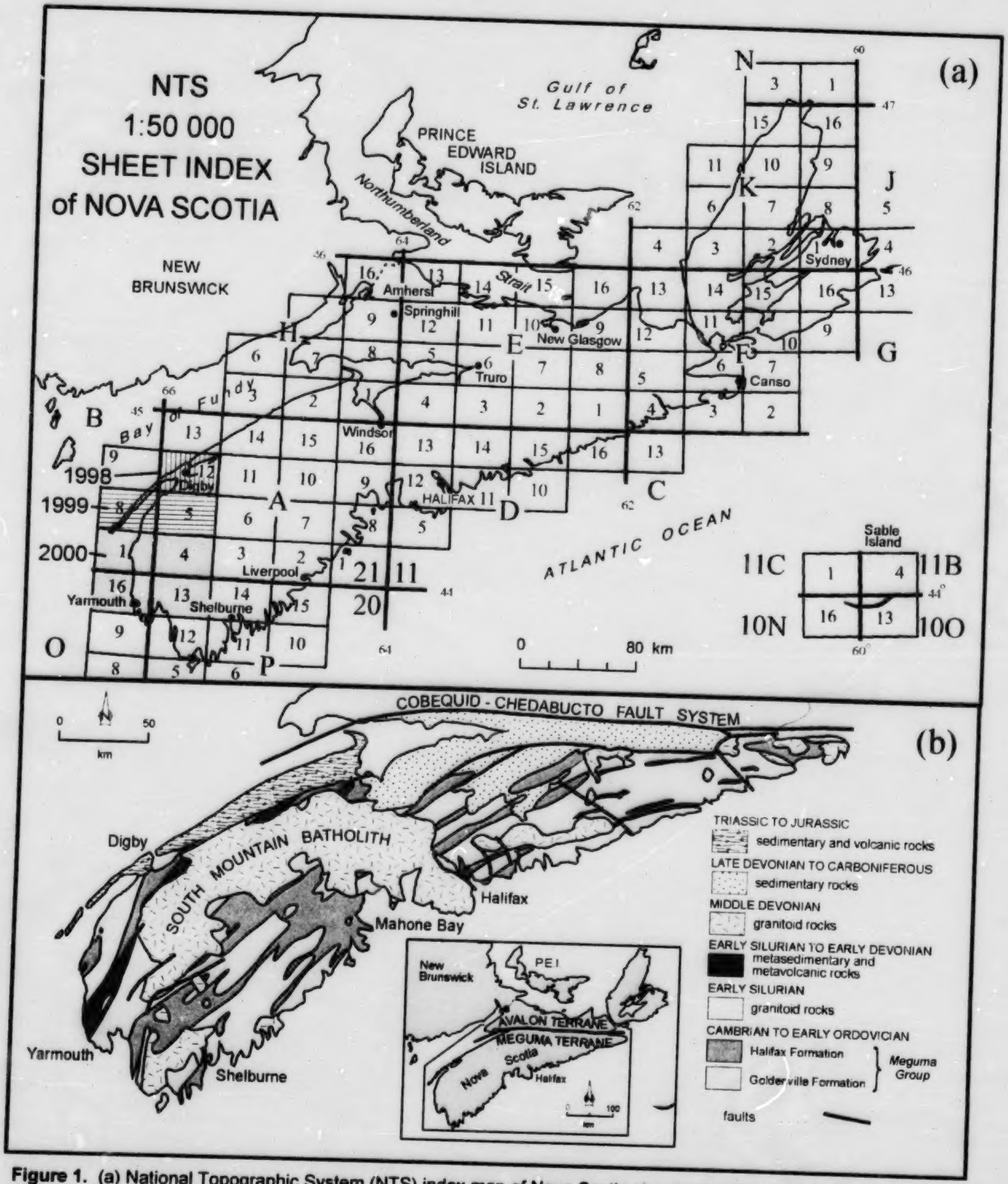

(a)
NTS
1:50 000
SHEET INDEX
of NOVA SCOTIA
Gulf of
St. Lawrence
PRINCE
EDWARD
ISLAND
Northumberland
Strait
NEW
BRUNSWICK
Bay of Fundy
Amherst
Springhill
New Glasgow
Truro
Windsor
HALIFAX
Digby
Liverpool
Yarmouth
Shelburne
Sydney
Canso
ATLANTIC OCEAN
1998
1999
2000
N
K
J
H
E
F
G
B
A
D
C
O
P
21
11
20
Sable
Island
11C
11B
10N
10O
0
80 km
(b)
COBEQUID - CHEDABUCTO FAULT SYSTEM
0
50
km
Digby
SOUTH MOUNTAIN BATHOLITH
Halifax
Mahone Bay
Yarmouth
Shelburne
New Brunswick
PEI
AVALON TERRANE
MEGUMA TERRANE
Nova Scotia
Halifax
0
100
km
TRIASSIC TO JURASSIC
sedimentary and volcanic rocks
LATE DEVONIAN TO CARBONIFEROUS
sedimentary rocks
MIDDLE DEVONIAN
granitoid rocks
EARLY SILURIAN TO EARLY DEVONIAN
metasedimentary and metavolcanic rocks
EARLY SILURIAN
granitoid rocks
CAMBRIAN TO EARLY ORDOVICIAN
Halifax Formation
Goldenville Formation
Meguma Group
faults

Figure 1. (a) National Topographic System (NTS) index map of Nova Scotia showing locations of mapped areas related to the Southwest Nova Scotia Mapping Project. (b) Simplified geological map of the Meguma Terrane, Nova Scotia.

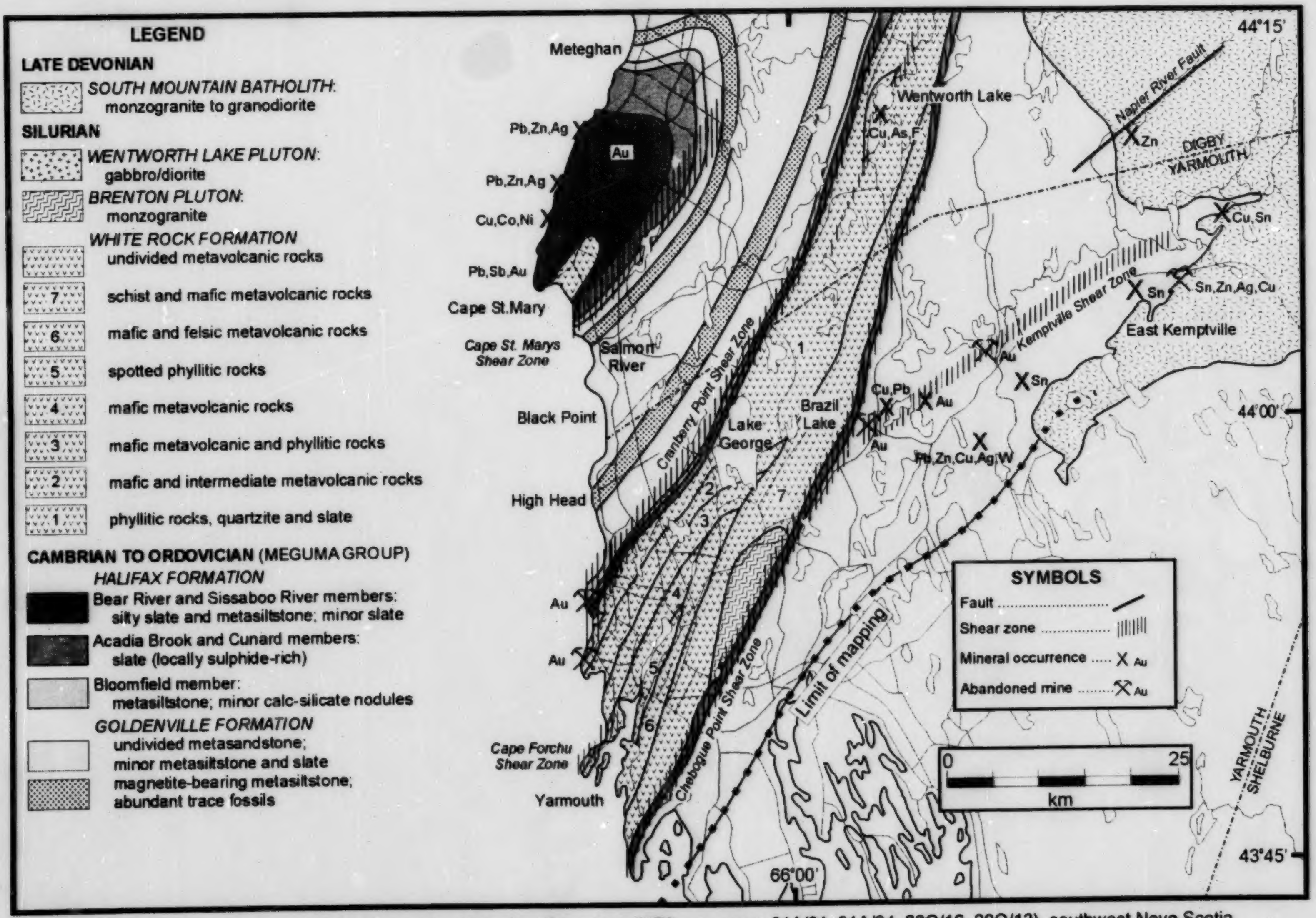

LEGEND
LATE DEVONIAN
SOUTH MOUNTAIN BATHOLITH: monzogranite to granodiorite
SILURIAN
WENTWORTH LAKE PLUTON: gabbro/diorite
BRENTON PLUTON: monzogranite
WHITE ROCK FORMATION
undivided metavolcanic rocks
7 schist and mafic metavolcanic rocks
6 mafic and felsic metavolcanic rocks
5 spotted phyllitic rocks
4 mafic metavolcanic rocks
3 mafic metavolcanic and phyllitic rocks
2 mafic and intermediate metavolcanic rocks
1 phyllitic rocks, quartzite and slate
CAMBRIAN TO ORDOVICIAN (MEGUMA GROUP)
HALIFAX FORMATION
Bear River and Sissaboo River members: silty slate and metasiltstone; minor slate
Acadia Brook and Cunard members: slate (locally sulphide-rich)
Bloomfield member: metasiltstone; minor calc-silicate nodules
GOLDENVILLE FORMATION
undivided metasandstone; minor metasiltstone and slate
magnetite-bearing metasiltstone; abundant trace fossils
Meteghan
Pb,Zn,Ag
Au
Pb,Zn,Ag
Cu,Co,Ni
Pb,Sb,Au
Cape St.Mary
Cape St. Marys Shear Zone
Salmon River
Black Point
High Head
Au
Au
Cape Forchu Shear Zone
Yarmouth
Cranberry Point Shear Zone
Lake George
Brazil Lake
Wentworth Lake
Cu,As,F
Napier River Fault
Zn
DIGBY
YARMOUTH
Cu,Sn
Kemptville Shear Zone
Sn
Sn,Zn,Ag,Cu
East Kemptville
Au
Sn
Cu,Pb
Au
Au
Pb,Zn,Cu,Ag,W
Chebogue Point Shear Zone
Limit of mapping
1
2
3
4
5
6
7
44°15'
44°00'
43°45'
66°00'
SYMBOLS
Fault
Shear zone
Mineral occurrence X Au
Abandoned mine Au
0
25
km
YARMOUTH
SHELBURNE

Figure 2. Simplified geological map of the Yarmouth - Meteghan River area (NTS map areas 21A/01, 21A/04, 20O/16, 20O/13), southwest Nova Scotia.

Halifax Formation

In the previously mapped areas to the north, the Halifax Formation was subdivided into three stratigraphic units including, from oldest to youngest, the Bloomfield, Acacia Brook/Cunard and Bear River/Sissiboo River members (White *et al.*, 1999; Horne *et al.*, 2000). Only the Bloomfield and Cunard members can be traced into the current map area; however, rocks characteristic of the Bear River/Sissiboo River member may be present in the Cape St. Mary area (Fig. 2), but more detailed mapping is need to confirm the distribution of these units.

Bloomfield Member

In the Cheboque Point area (Fig. 2) the Bloomfield member consists of a thin (<20 m) unit of grey-green, well-laminated metasiltstone and slate. The contact with the Goldenville Formation is abrupt and marked by a boudinaged mafic sill (<30 cm thick). Gradationally overlying the Goldenville Formation in the Cranberry Point area (Fig. 2), the Bloomfield member consists of a 200 m thick, locally well crenulated, phyllite to spotted phyllite. North of Salmon River (Fig. 2) the Bloomfield member consists of a 200 m thick, strongly sheared, uniform, greenish slate and metasiltstone. The contact with the underlying Goldenville formation, consisting of metasandstone and minor metasiltstone, is exposed and abrupt. The contact with the overlying Cunard member is gradational, defined by a 30 m wide zone with increasing black slate layers. Although well exposed along the coast, tracing the inland extent of the Bloomfield member is difficult due to poor outcrop control and lack of a significant aeromagnetic signature.

Cunard Member

Conformably overlying the Bloomfield member is black to rust-brown slate with minor (<10 to 50 cm thick) metasandstone layers of the Cunard member. Pyrite and pyrrhotite are common. This unit is typical of the Cunard member exposed to the north (Horne *et al.*, 2000) and elsewhere in the Meguma Group (e.g. Schenk, 1995). This unit corresponds to a high aeromagnetic signature which can be traced inland (Fig. 3).

White Rock Formation

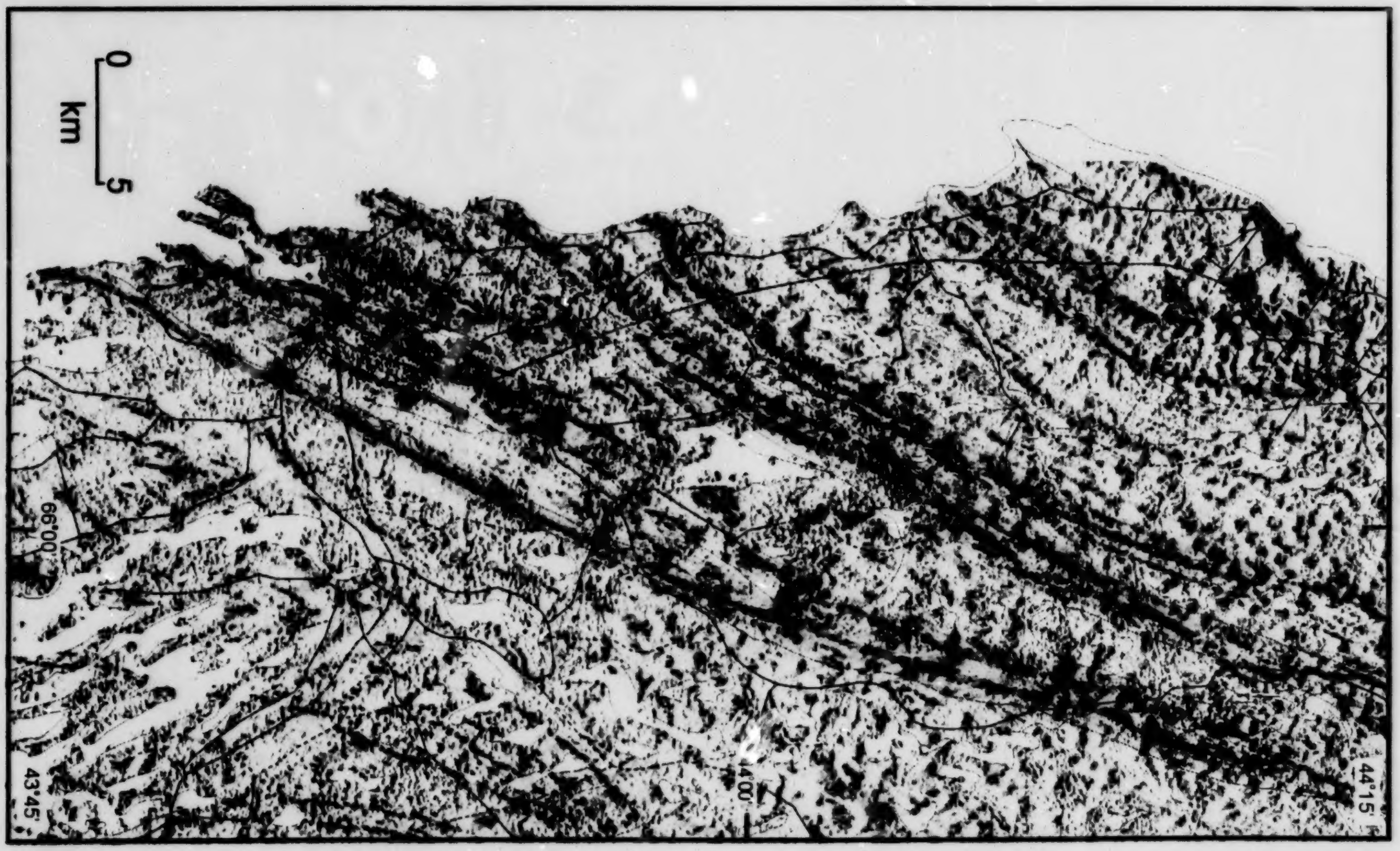
Introduction

The White Rock Formation is well exposed in coastal sections in the Yarmouth and Cape St. Marys areas (Fig. 2) and is composed mainly of metavolcanic rocks, in contrast to the entirely metasedimentary character of the unit in the northern map areas (e.g. White *et al.*, 1999; Horne *et al.*, 2000). Taylor (1965, 1967, 1969) interpreted the White Rock Formation in the Yarmouth area to occur in a syncline, as in the Bear River, Torbrook and Black River areas to the northeast, and subsequent workers did not significantly modify this interpretation (e.g. Lane, 1979; Hwang, 1985; Schenk, 1995, 1997; Culshaw, 1994; Culshaw and Liesa, 1997; MacDonald, 2000). Although the aeromagnetic data also suggest a synclinal structure, our mapping in the area indicates that the structure may be more complicated than a single syncline. In the Cape St. Marys area, the White Rock Formation was also interpreted to occur in a syncline and based on aeromagnetic data and limited field work this interpretation appears to be valid; however, more detailed mapping is needed for confirmation.

Due to deformation and greenschist- to amphibolite-facies metamorphism, many primary sedimentary and volcanic features within the White Rock Formation have been obliterated. However, in many cases the protolith can still be inferred and, where possible, the protolith name is used here. Geochemistry of mafic volcanic rocks in the White Rock Formation indicates an alkalic affinity and a within-plate tectonic setting and the felsic volcanic rocks have some characteristics similar to within-plate A-type granites (MacDonald, 2000).

Based on exposures along the coastal sections, the White Rock Formation can be subdivided into seven units. However, the lack of outcrop in some areas precludes extending, with confidence, many of these units inland. The combined DEM and high-resolution second derivative aeromagnetic data (Fig. 3) assist in tracing units from the coast into areas of lesser outcrop because in many places a reasonably good correlation occurs between rock type and magnetic signature. However, in some places where outcrop control is reasonably good, it is apparent that some geological units exhibit a change in magnetic signature along strike. Such changes make area-wide correlation of magnetic signature and rock unit difficult. In this preliminary report, emphasis is on the description of units based on coastal sections and on inland distribution of units for which outcrop data and magnetic signature are in agreement. Although the White Rock Formation in the Yarmouth area may have been originally folded into a regional syncline, based on the coastal exposures, the units of the White Rock Formation appear to be right-way-up and younging to the east, with no obvious repetition of units, suggesting that the syncline no longer exists.

Figure 3. Grey-scale calculated second derivative aeromagnetic image, gridded to a 75 m cell size, combined with the digital elevation model (DEM) with shading from the west at 45°.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km
44°15'
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43°45'

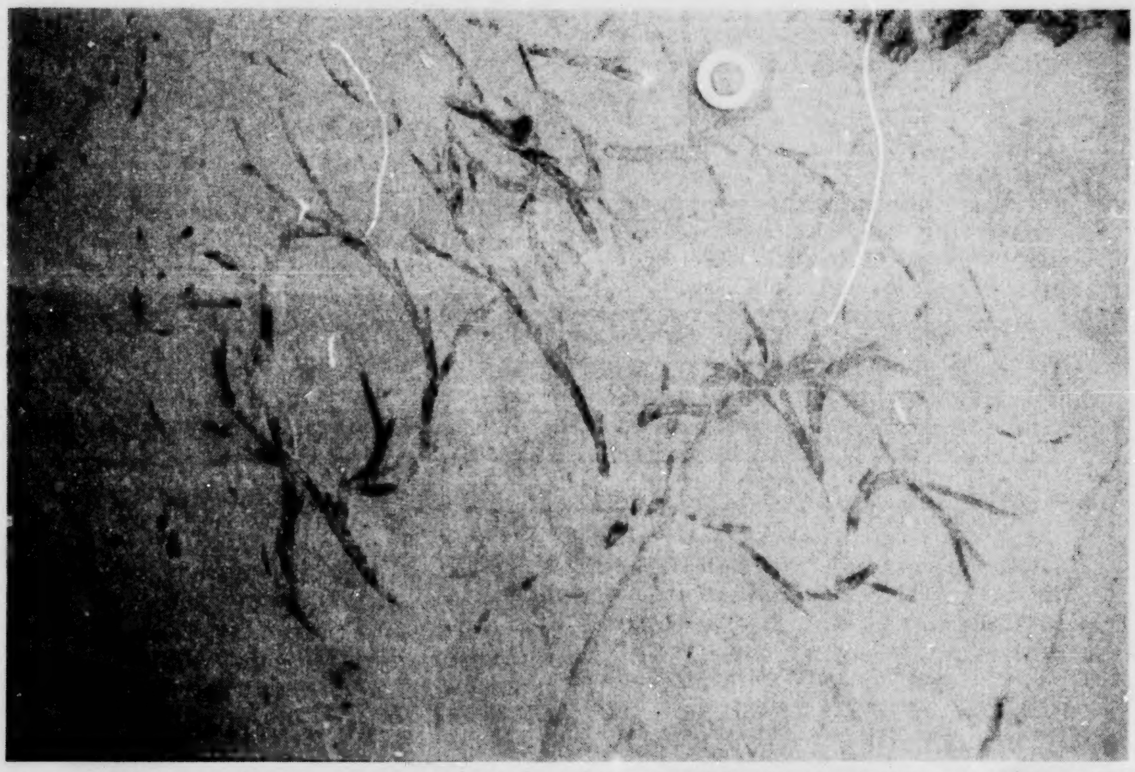

Figure 4. Photograph of the upper bedding plane surface of a horizontally laminated metasiltstone displaying large grazing and burrowing traces. Sample from the magnetite-bearing metasiltstone unit in the Goldenville Formation. Two-dollar coin for scale.

Unit 1

The stratigraphically lowest unit in the White Rock Formation is dominantly metasedimentary consisting of tuffaceous metasandstone, metasiltstone, slate and quartzite. It is exposed from Cranberry Head to Chegoggin Point (Fig. 2). The contact with the underlying Halifax Formation is not exposed. Unit 1 broadly corresponds to the basal metasedimentary and quartzite units defined by MacDonald (2000).

The lowest part of unit 1 consists of grey, well cleaved, tuffaceous metasandstone to metasiltstone. Small biotite and/or amphibole porphyroblasts (<2 mm in width) are abundant. Locally, elongate (up to 2 by 5 cm) amphibolite clasts are common. Calc-silicate beds (up to 20 cm thick) and lenses are common and typically display metamorphic zoning defined by varying amounts of amphibole and epidote. Upwards, this unit becomes interlayered with dark grey, laminated phyllite and slate, the latter containing trace fossils. The slate and phyllite grade upward into spotted metasiltstone which locally contains garnetiferous schist layers (up to 2 m thick) associated with sulphide-rich metasandstone. Chloritoid is locally abundant. The spotted metasiltstone interval coincides with a high aeromagnetic signature that "pinches-out" inland (Fig. 3). At the top of this unit the spotted metasiltstone abruptly changes to thickly bedded, massive to well-laminated quartzite layers (Fig. 5). Based on drill core data and sporadic outcrops of quartzite, unit 1 can be traced to the Lake George area (Fig. 2).

Unit 2

Above the quartzite of unit 1 is a metavolcanic unit with minor tuffaceous metasandstone similar to the metavolcanic unit described by MacDonald (2000) which overlies the quartzite. The lower contact with the quartzite is well exposed at low tide at Chegoggin Point. At that location, dark green mafic crystal and lithic crystal tuff are interlayered with minor pink, intermediate to felsic crystal to crystal lithic tuff. About 100 m above the base of this unit, a quartzite similar to those in unit 1 occurs as large (up to 2 by 2 m) boudins in the mafic tuff. The mafic tuff coincides with a high areomagnetic signature that can be traced to the Lake George area (Fig. 3). The remainder of the unit is

Figure 5. Photograph of massive quartzite (light) interlayered with thin amphibolite (dark) in the upper part of Unit 1. Backpack in centre for scale.

poorly exposed along the coast, with only rare inland outcrops, and displays a low aeromagnetic signature (Fig. 3). Interpreted to conformably overlie the mafic tuff is a sequence of light grey tuffaceous metasandstone interlayered with thinly bedded, spotted metasiltstone, metasandstone and actinolite-rich tuff. At the inferred top of this unit is a section of grey andesitic lithic to lithic crystal tuff.

Unit 3

Unit 3 is composed predominantly of mafic volcanic and metasedimentary rocks. The lower part of the unit is exposed inland along a string of discontinuous topographic highs where outcrops consist of amphibolitized mafic lithic tuff and flows. The contact with the andesitic tuff of unit 2 is not exposed but the highly deformed character of the most southeasterly outcrops of andesite suggests a tectonic contact. The middle and upper parts of the unit are well exposed along the coast near Overton and Cape Forchu West. The middle part of this unit consists of well laminated, spotted metasiltstone and metasandstone, locally interlayered with amphibole-rich tuffaceous metasandstone and mafic crystal tuff and flows. In the middle of this section is a rust-brown, 2 m wide, massive quartzite layer. This quartzite differs from the quartzite in units 1 and 2 in its association with pillow basalt and the presence of rare brachiopod fossils. Calc-silicate lenses (20 cm thick) are common in the metasedimentary rocks and, like those in unit 1, typically display metamorphic zoning defined by varying amounts of amphibole and epidote. Also present are abundant trace fossils of *chondrites*. Up-section, the metasedimentary package is in sharp contact with a thick (<200 m) package of mafic lithic to lithic crystal tuff and associated flows interlayered with minor tuffaceous metasandstone. The top of unit 3 is marked by felsic crystal tuff with conglomeratic layers (Fig. 6) containing abundant elongate (up to 50 by 5 cm), mafic to felsic clasts.

This unit has a composite aeromagnetic signature and is therefore difficult to trace inland. In areas of good inland outcrop control (i.e. basaltic rocks at the base of this unit), the magnetic signature along strike varies between positive to negative amplitudes. Whether this is a result of the resolution of the aeromagnetic data or the magnetic character of the basaltic unit needs to be investigated further. This unit is equivalent to the mafic to felsic volcanic and metasiltstone unit defined by MacDonald (2000).

Unit 4

Unit 4 consists predominantly of mafic volcanic rocks and is best exposed along the northwestern shore of Yarmouth Harbour. The lower part of this unit is exposed at Cape Forchu West and consists of green to dark grey, massive mafic flows and lithic tuff. These are locally interlayered with minor tuffaceous metasandstone containing abundant small (<2 mm in length) amphibole porphyroblasts. The contact with unit 3 is sharp and marked by a narrow shear zone. The middle part of the unit consists of mafic lithic tuff interlayered with abundant tuffaceous sandstone (Fig. 7a). In contrast to the lower unit, this unit is thinly bedded to well laminated with original sedimentary and volcanic textures well preserved (Fig. 7b). In addition, many of the tuffaceous metasandstone layers contain calc-silicate lenses. The upper part of this unit consists of green, massive mafic flows and lithic to crystal lithic tuff. Locally the flows have pillow-like structures or brecciated flow tops. The associated lithic tuff contains abundant tuffaceous metasandstone and amygdaloidal basalt clasts. Locally plagioclase crystals (up to 1 cm in width) are abundant. The upper and middle packages are separated by a shear zone. In comparison to the stratigraphy defined by MacDonald (2000), the lower part of the unit corresponds to the mafic flows/tuff and conglomerate unit, whereas the middle and upper parts are broadly equivalent to uppermost mafic tuff and flows.

Unit 5

Unit 5 consists predominantly of metasedimentary rocks and is best exposed along the eastern shore of Yarmouth Harbour. The lower part of this unit contains thickly bedded metasandstone with abundant calc-silicate nodules interlayered with grey, biotite-spotted slate. Minor thin (<1 cm thick) limy beds are present. The middle part of the unit is mainly spotted slate interbeded with metasiltstone. Metasandstone layers and lenses are rare. Near the top of the unit, the metasedimentary rocks are interlayered with mafic lithic tuff and flows and tuffaceous metasandstone. The contact with unit 4 is not exposed but, because of a topographic linear, is interpreted to be a fault. This unit corresponds to the "black slate" in the upper unit of MacDonald (2000).

Unit 6

Above unit 6, in gradational contact, are mafic lithic tuff and flows interlayered with minor tuffaceous metasandstone. This unit is well exposed at Sunday Point. The metavolcanic rocks are very similar to the upper part of unit 4, but in contrast, many of the mafic layers in unit 6 contain peperite-like textures. In addition, two distinctive felsic crystal tuff layers (< 100 m thick) exist in this unit that are not present in unit 4. The most westerly felsic layer can be traced several kilometres inland. The felsic crystal tuff has yielded a U-Pb zircon age of 438 +3/-2 Ma, interpreted to be the time of crystallization of the tuff (J. Ketchum, unpublished data, cited by MacDonald, 2000). Because MacDonald (2000) interpreted the White Rock Formation to be folded into a syncline, this unit is similar to the mafic flows/tuff and conglomerate unit on the eastern limb of the syncline.

Unit 7

The stratigraphically highest unit in the White Rock Formation in the Yarmouth area is dominantly a mixture of metasedimentary and metavolcanic rocks. The metasedimentary rocks consist of biotite ± garnet ± staurolite-bearing phyllite and schist, locally interlayered with thin layers (<30 cm thick) of metasandstone and amphibolite. The metasedimentary rocks have a low areomagnetic signature. The metavolcanic rocks consist of green mafic to rare intermediate lithic tuff interlayered with tuffaceous metasandstone. They form a distinct belt in the centre of the metasedimentary unit, which is also defined by a strong areomagnetic signature. Large areas of medium- to coarse-grained amphibolite occur in this unit (i.e. Brazil Lake area) but because of lack of any primary features it difficult to ascertain the protolith. Quartzite layers are rare and have been observed interlayered with the amphibolite in the Brazil Lake area. These amphibolites have a low areomagnetic signature. This unit is equivalent to parts of the lower- most units defined by MacDonald (2000).

Intrusive Rocks

Mafic Sills

Compared to map areas to the north (e.g. White *et al.*, 1999; Horne *et al.*, 2000), mafic sills in the Goldenville and Halifax formations are not as abundant and, therefore, more difficult to subdivide into distinct suites (cf. White *et al.*, 1999). The sills are locally foliated, fine- to medium-grained and 1-2 m thick. The White Rock Formation contains numerous mafic sills that are typically foliated, medium- to coarse-grained and boudinaged parallel to foliation. Although the sills in the WRF are now composed of amphibolite, some display a phenocryst-rich or amygdaloidal zone near the upper contact, which suggests that they may represent mafic flows younging to the southeast, rather than sills. Cross-cutting mafic bodies (dykes) are rare. Geochemical work is in progress on the mafic sills.

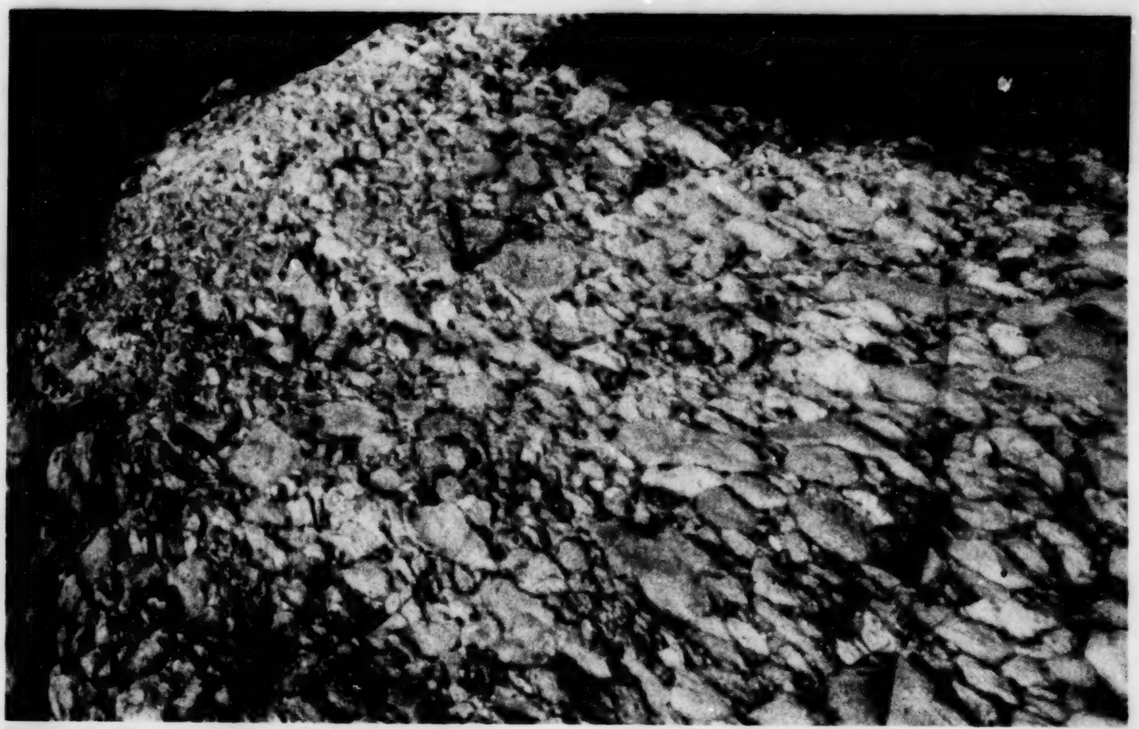

Figure 6. Photograph of conglomerate layer in the upper part of Unit 3. Clasts are dominantly intermediate crystal tuff and tuffaceous sandstone. Hammer for scale.

Gabbroic and Dioritic Rocks

Small gabbroic and dioritic bodies outcrop in the Goldenville Formation near Sandford, in the Halifax Formation near Mavillette, and in the White Rock Formation in Wentworth Lake (Fig. 3). The intrusion near Sanford is well exposed along the coast and consists of relatively undeformed, homogeneous, medium-grained diorite. The age of the diorite is unknown but it clearly intruded metasandstone along the eastern margin and has a faulted contact on the south. Petrographic and petrochemical studies are in progress to further characterize this intrusion. The Mavillette Intrusion (Calder and Barr, 1982) is a small dyke-like body of medium-grained, ophitic gabbro. Locally it is coarse-grained, pegmatitic and strongly deformed. Like the Sandford intrusion, the age is unknown. The Wentworth Lake intrusion is well exposed on islands in Wentworth Lake. Contact relations with the surrounding staurolite and chloritoid-bearing metasedimentary rocks of the White Rock Formation are not exposed. The intrusion consists of unfoliated, medium- to coarse-grained diorite to quartz diorite (Ham and MacDonald, 1994). Toward the eastern margin, the diorite becomes increasingly deformed and grades into mylonite. There is no direct evidence for the age of this intrusion, although Ham and MacDonald (1994) assigned a Middle Devonian or earlier age. Relatively fresh gabbroic sills occur in the Goldenville Formation in the Chebogue Point area and may be related to Early Mesozoic mafic dykes that occur in the Goldenville Formation and Carboniferous Wedgeport Pluton exposed farther east (Pe-Piper and Reynolds, 2000). Geochemical work is in progress on the gabbroic and dioritic intrusions.

Brenton Pluton

The Brenton Pluton (Taylor, 1967) is a narrow northeast-trending body in the southeastern part of the map area. It consists dominantly of a grey, medium-grained syenogranite to monzogranite (O'Reilly, 1976; MacDonald, 2000) that is typically strongly foliated and lineated. Locally, in the central parts of the pluton, the granite is unfoliated, massive and equigranular. The western contact is faulted against unit 7 of the White Rock Formation and the eastern contact is faulted against the Cunard member of the Halifax Formation. In contrast to previous work, no contact metamorphic aureole was observed (cf. Taylor, 1967; O'Reilly, 1976; Hwang, 1985). The Brenton Pluton has yielded a U-Pb crystallization age of ca. 439 Ma (Keppie and Krogh, 2000). Geochemistry of the granitic rocks suggests some characteristics similar to within-plate A-type granites (MacDonald, 2000).

South Mountain Batholith

Because the geology of the South Mountain Batholith was part of an earlier detailed study (Ham and MacDonald, 1994), it was not remapped in detail during the present study. The batholith in the study area consists of medium- to coarse-grained monzogranite to leucogranite with locally well-developed megacrysts of K-feldspar. The South Mountain Batholith has yielded U-Pb crystallization ages of ca. 370 Ma (Clarke *et al.*, 1993; Harper, 1988).

Metamorphism

The Meguma Group, White Rock Formation and mafic sills were deformed during the Acadian Orogeny. This deformation resulted in regional scale northeast-trending folds with an axial planar cleavage. The regional deformation was accompanied by greenschist- to amphibolite-facies metamorphism that resulted in the southeastward increase in metamorphic grade from chlorite zone (Meteghan to Cape St. Marys), through biotite zone (Cape St. Marys to Cranberry Point), to garnet zone (Cranberry Point to Sunday Point) (Keppie and Muecke, 1979; O'Reilly, 1976; Hwang, 1985; Culshaw, 1994; Culshaw and Liesa, 1997). Recent studies by MacDonald (2000) further defined a staurolite zone along the southeastern contact between the White Rock and Halifax formations, indicating amphibolite facies conditions (Yardley, 1989). In addition, biotite is present in some areas within the chlorite zone. Whether this is a compositional feature of the original rock type or related to higher metamorphic grade is as yet unclear. Rocks of the Goldenville Formation southeast of the White Rock Formation have mineral assemblages characteristic of the chlorite and biotite zones, although locally contact metamorphism produced andalusite and cordierite-bearing assemblages. Associated with the deformation and metamorphism was the development of an axial planar penetrative slaty, to phyllitic, to schistose foliation.

Typical syntectonic metamorphic mineral assemblages in pelitic rocks include chlorite + muscovite + quartz + albite in the chlorite zone; biotite + chlorite + muscovite + quartz + albite in the biotite zone; garnet + biotite + chlorite + muscovite + quartz + albite + epidote ± chloritoid in the garnet zone; and staurolite + garnet + biotite + muscovite + quartz + plagioclase ± chlorite in the staurolite zone. Mafic volcanic rocks and sills in the chlorite and biotite zone typically retain their original igneous textures but their mineral assemblage is metamorphic, including chlorite + epidote + actinolite ± quartz. In the garnet and staurolite zones original textures are typically obliterated and actinolite is replaced by hornblende (cf. Sarkar, 1978; MacDonald, 2000).

O'Reilly (1976) and Hwang (1985) reported evidence of a contact metamorphic aureole around the Brenton Pluton. However, the high metamorphic grade along the northern and western margins of the pluton is consistent with the regional amphibolite grade of metamorphism in unit 7 of the White Rock Formation (e.g. MacDonald, 2000).

The precise age of metamorphism is difficult to determine. A detailed $^{40}Ar/^{39}Ar$ study on single grain muscovite and whole-rock samples from the Meguma Group in the Digby area indicated that regional greenschist-facies metamorphism associated with the Acadian Orogeny occurred ca. 400 Ma (Muir, 2000). This age is similar to $^{40}Ar/^{39}Ar$ ages reported elsewhere in the Meguma Group (405-390 Ma, Muecke *et al.*, 1988; 395-388 Ma, Hicks *et al.*, 1999). However, the timing of amphibolite-facies metamorphism in the study area may be constrained by metamorphic monazite from the Brenton Pluton, which yielded a U-Pb age of 380±3 Ma (Keppie and Krogh, 2000). Published $^{40}Ar/^{39}Ar$ muscovite and biotite ages from the Meguma Group, White Rock Formation and Brenton Pluton in the map area yielded considerably younger ages between 330 and 310 Ma (O'Reilly, 1976; Reynolds *et al.*, 1981; Dallmeyer and Keppie, 1987; Culshaw and Reynolds, 1997). An $^{40}Ar/^{39}Ar$ study on whole-rock samples from the Goldenville Formation northeast of the East Kemptville Mine yielded ages in the range 315 to 300 Ma (Keppie and Dallmeyer, 1995). These younger ages suggest a more complex tectonic history for the area than previously thought (e.g. Taylor, 1967, 1969; Lane, 1979; Hwang, 1985; Schenk, 1995, 1997), and may be related to a younger regional metamorphism or plutonism (e.g Keppie and Dallmeyer, 1995), or to deformation related to shear zone development (e.g. Culshaw and Reynolds, 2000).

Deformation

Previous published maps of the area show the metamorphic rocks are deformed into a series of regional D_1 folds with the Goldenville Formation exposed in the Black Point anticline (Culshaw and Liesa, 1997) and the Halifax and White Rock formations are exposed in the Cape St. Marys and Yarmouth synclines (Taylor, 1967, 1969). The Cape St. Marys syncline is part of a larger synclinorium termed the Bear Cove synclinorium (Culshaw and Leisa, 1997). In

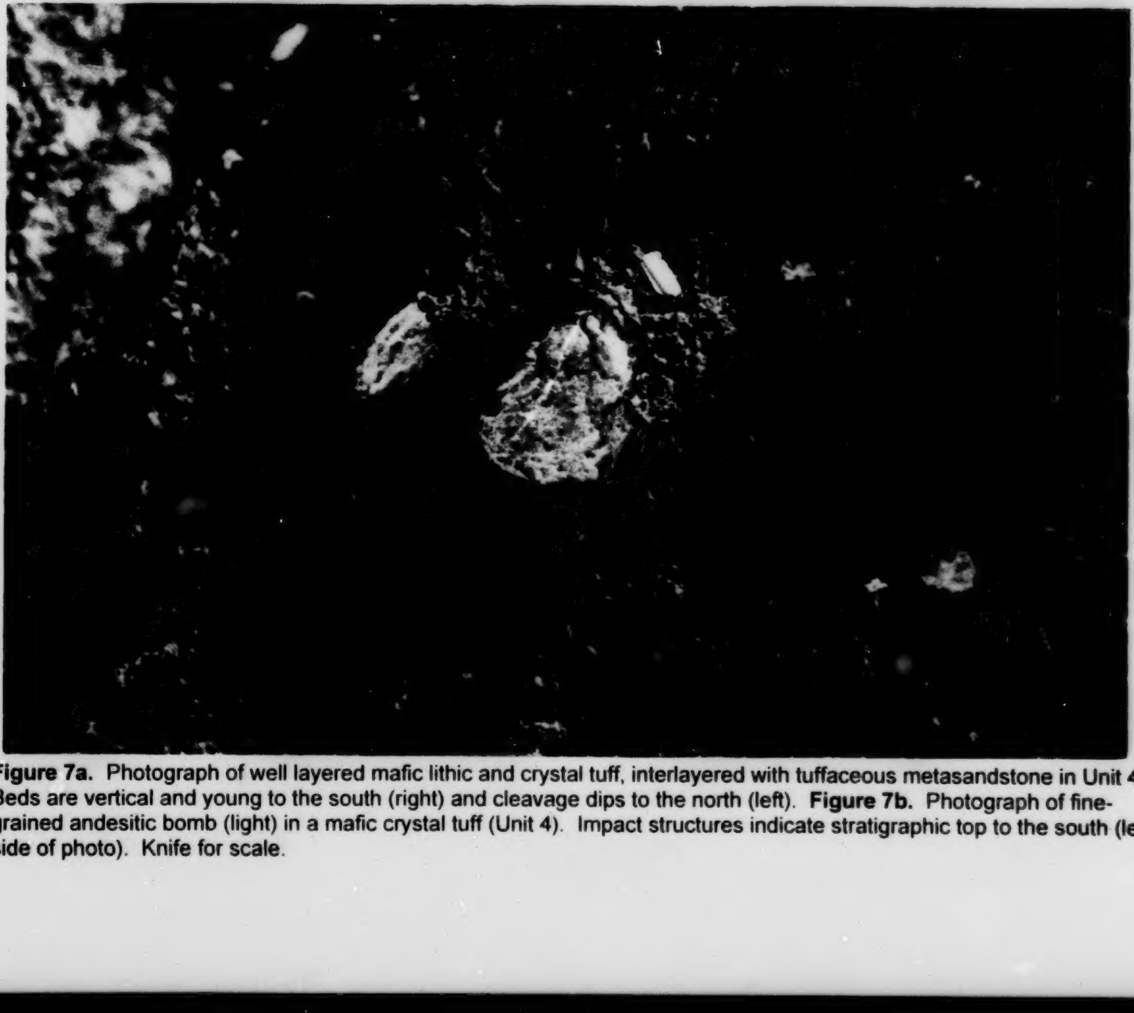

Figure 7a. Photograph of well layered mafic lithic and crystal tuff, interlayered with tuffaceous metasandstone in Unit 4. Beds are vertical and young to the south (right) and cleavage dips to the north (left). **Figure 7b.** Photograph of fine-grained andesitic bomb (light) in a mafic crystal tuff (Unit 4). Impact structures indicate stratigraphic top to the south (left side of photo). Knife for scale.

addition, several shear zones have been documented within the map area (Hwang, 1985; O'Reilly *et al.*, 1992; Ham and MacDonald, 1994; Keppie and Dallmeyer, 1995; Culshaw, 1994; Culshaw and Liesa, 1997). Our mapping generally agrees with this earlier interpretation; however, we differ in the interpretation of the present existence of the "Yarmouth syncline". Although the White Rock Formation in the Yarmouth area may have been originally folded into a regional syncline, and the presence of the Halifax Formation on either side of the White Rock Formation indicates a synclinal structure (Fig. 2), regionally the map units in the White Rock Formation systematically young from west to east with no apparent repetition of units. In addition, the aeromagnetic data combined with the preliminary stratigraphy in the Goldenville Formation on either side of the White Rock Formation do not appear to correlate (Fig. 3). The presence of major shear zones in the area may help explain some of the structural complexities but more detailed studies are need to completely address this problem.

For descriptive purposes, the area is divided into three F_1 structural domains. Domain I comprises the Goldenville and Halifax formations in the Black Point anticline and Cape St. Marys synclinorium in the northwestern part of the map area (Fig. 8). The rocks in this zone are regionally metamorphosed to greenschist facies. Domain II includes all the White Rock Formation in the central part ("Yarmouth syncline") of the map area (Fig. 8). In this domain, metamorphism increases from greenschist facies in the east to amphibolite facies in the west. Domain III comprises the Goldenville and Halifax formations in the southeastern part of the map area (Fig. 8) where they are regionally metamorphosed to greenschist facies.

F_1 Folds

Poles to bedding in Domain I define a girdle distribution with a shallow, southwest-plunging fold axis (208/13) and poles to foliation define a well-developed cluster with a steep axial planar foliation that strikes northeast (Fig. 8). Intersection lineations (L_1), although somewhat scattered, have an average southwest plunge, similar to the calculated fold axis from bedding orientations (Fig. 8). However, intersection lineations also plunge to the northeast suggesting doubly plunging folds. Steep lineations are likely the result of re-orientation during younger deformation (cf. Culshaw and Leisa, 1997). Minor F_1 folds are not common and, where present, are restricted to the Bear Cove synclinorium and are upright subhorizontal folds (Culshaw, 1994; Culshaw and Leisa, 1997). The regional fold pattern indicates that the Black Point anticline and Cape St. Marys synclinorium are moderately inclined to the northwest and plunge gently to the southwest with an overturned northwestern limb on the Black Point anticline (cf. Culshaw and Leisa, 1997).

Poles to bedding and volcanic layering in the White Rock Formation (Domain II) form a well defined cluster with an average bedding that strikes north-northeast and dips steeply to the east and also forms an incipient girdle distribution about a shallow southwest-plunging fold axis (194/14) (Fig. 8). Poles to foliation define a well developed cluster with an average orientation that strikes north-northeast with a vertical dip (Fig. 8). Intersection lineations (L_{1a}) parallel the long axis of elongate clasts (L_{1b}) and form a well developed, shallow, southwest-plunging cluster similar to the calculated fold axis from bedding orientations (Fig. 8). Minor F_1 folds are rare and restricted to the more pelitic rocks. They are steeply inclined and plunge gently to the south (Fig. 8).

Structural data in Domain III are similar top those in Domain I. Poles to bedding are somewhat scattered but still form a weak girdle distribution about a northeast-plunging axis and poles to foliation define a well developed cluster with a steep axial planar foliation that strikes northeast (Fig. 8). Average intersection lineations (L_1) form a shallow, southwest-plunging cluster; however, intersection lineations also plunge to the northeast suggesting doubly plunging folds.

F_2 Folds

Although minor F_2 crenulation fabrics are common in all rocks in the map area, mesoscopic-scale F_2 folds are more common in the White Rock Formation. Here, the foliation and bedding are locally deformed into upright, gently south-southeast-plunging F_2 folds (Fig. 8) with northeast-trending steep (S_2) axial planar foliation. The long axes of elongate clasts are parallel to the F_2 fold axis. The similarity in structural geometry between F_1 and F_2 folds suggests that deformation was coplanar.

Boundary Shear Zones

Numerous shear zones along lithological boundaries have been documented in the map area (Fig. 8) and are exposed mainly in coastal area. These include the Cape St. Marys, Cranberry Point, Cape Forchu and Chebogue Point shear zones of Culshaw (1994) and Culshaw and Liesa (1997). The Cape St. Marys, Cranberry Point and Chebogue Point shear zones have predominantly dip-slip displacement, although a significant strike-slip component is locally evident, whereas the Cape Forchu shear zone displays evidence for strike-slip motion (Culshaw and Liesa, 1997). The Cape St. Marys and

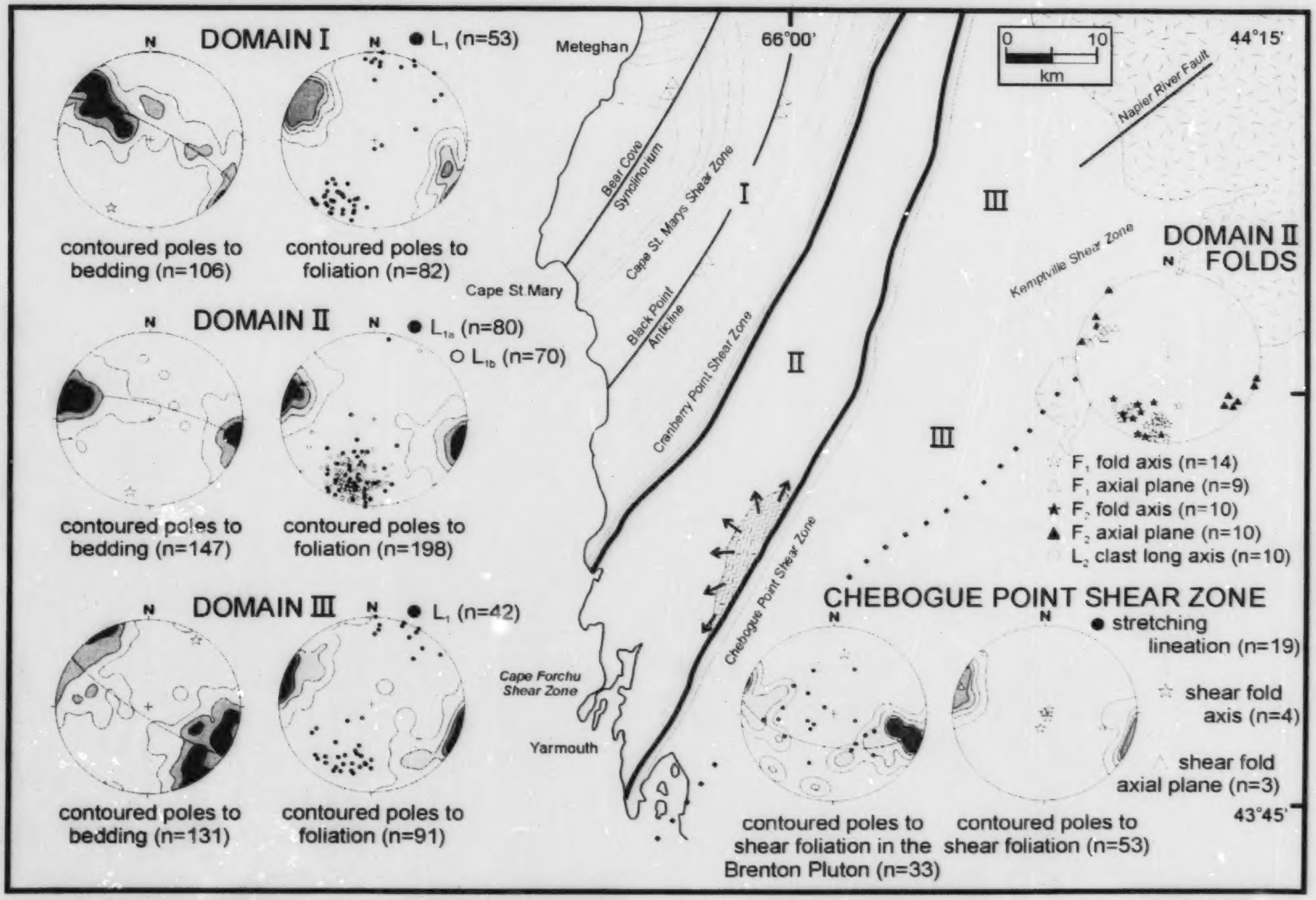
DOMAIN I
N
● L_1 (n=53)
contoured poles to bedding (n=106)
contoured poles to foliation (n=82)
DOMAIN II
● L_{1a} (n=80)
○ L_{1b} (n=70)
contoured poles to bedding (n=147)
contoured poles to foliation (n=198)
DOMAIN III
● L_1 (n=42)
contoured poles to bedding (n=131)
contoured poles to foliation (n=91)
Meteghan
Cape St.Mary
Cape Forchu Shear Zone
Yarmouth
66°00'
Bear Cove Synclinorium
Cape St. Marys Shear Zone
Black Point Anticline
Cranberry Point Shear Zone
Chebogue Point Shear Zone
Kemptville Shear Zone
Napier River Fault
I
II
III
0 10 km
44°15'
43°45'
DOMAIN II FOLDS
F_1 fold axis (n=14)
F_1 axial plane (n=9)
★ F_2 fold axis (n=10)
▲ F_2 axial plane (n=10)
L_2 clast long axis (n=10)
CHEBOGUE POINT SHEAR ZONE
● stretching lineation (n=19)
☆ shear fold axis (n=4)
shear fold axial plane (n=3)
contoured poles to shear foliation in the Brenton Pluton (n=33)
contoured poles to shear foliation (n=53)

Figure 8. Stereographic projections displaying structural data from the map area. Units as in Figure 2. Contours on steronets represent 1, 3, 5, and greater than 7% per 1% area; darkest shading indicates highest contour area. Arrows in Brenton Pluton represent stretching lineations. L terminology explained in text.

Cranberry Point shear zones have yielded ca. 320 Ma muscovite ages indicating a middle Carboniferous age for shear zone development (Culshaw and Reynolds, 1997). Our mapping has delineated several other shear zones, some of which may or may not correlate with those described above. Narrow, steeply dipping, northeast-trending shear zones occur in the Goldenville Formation southwest of the White Rock Formation (Ham and MacDonald, 1994), and locally display significant Sn-Cu-Au mineralization (O'Reilly, 1995).

The most significant shear zone is the Chebogue Point shear zone (Deerfield shear zone of Keppie and Dallmeyer, 1995). The Chebogue Point shear zone forms a wide belt along the southeastern contact between the White Rock and Goldenville formations, incorporating the majority of the Halifax Formation (Fig. 2). Inland the shear zone appears to encompass most of the Brenton Pluton and surrounding staurolite schist of the White Rock Formation. The shear zone juxtaposes chlorite and biotite grade zone of the Halifax and Goldenville formations and staurolite zone metamorphic rocks of the White Rock Formation (cf. Hwang, 1985). At Chebogue Point kinematic indicators suggest west-side-up dip-slip motion (Culshaw and Liesa, 1997), whereas Dallmeyer and Keppie (1987) and Keppie and Dallmeyer (1995) argued for dextral shear. This zone is strongly overprinted by younger brittle deformation that locally obliterates earlier deformational textures.

Poles to shear foliation form a well defined cluster with a steep, north-northeast trending orientation (Fig. 8). Rare folds in this zone are steeply plunging with axial planes subparallel to the average foliation (Fig. 8), suggesting a strike-slip motion. Poles to foliation in the Brenton Pluton form a well defined cluster with a foliation that strikes north-northeast and dips steeply to the northwest and also forms an incipient girdle distribution about a shallow north-plunging fold axis (Fig. 8). Isoclinal, infrafolial folds are rare. Stretching lineations appear to be scattered on the stereonet but in the field seem to have a very systematic "domal" distribution, plunging to the southwest, west, and northwest along the western margin and to the east and northeast on the eastern margin (Fig. 8). The domal stretching lineation pattern suggests a sheath-fold geometry.

The Kemptville shear zone (O'Reilly, 1995) is a northeast-trending mylonitic shear zone that is well developed in metasandstone of the Goldenville Formation. It can be traced from East Kemptville to Carleton where it appears to be truncated by the Chebogue Point shear zone (Fig. 2 and 8). The shear zone is steeply dipping and records a dip-slip, southeast-side-up shear sense (Horne and White, 2000).

Economic Geology

Numerous tin, base metal, and precious metal occurrences are known in the map area (Fig. 2) and are described in the Nova Scotia Department of Natural Resources Mineral Occurrence Database for NTS map sheets 21A/01, 21A/04, 20O/16, 20O/13. The most significant mineral deposit in the area is the greisen-hosted East Kemptville Sn-Zn-Cu-Ag deposit in the South Mountain Batholith (e.g. Kontak, 1990). Smaller, granite-hosted deposits include the Li-Be-bearing pegmatite at Brazil Lake (e.g. MacDonald et al., 1992) and a copper showing in the dioritic Wentworth Lake intrusion (e.g. O'Reilly, 1978). The Goldenville Formation adjacent to the South Mountain Batholith is host to several Sn-Zn-Cu occurrences. The minerals typically occur in silicified and sericitized zones, or as statabound replacement associated with hydrothermally altered metasandstone, or in discordant vein systems (O'Reilly, 1995). The Goldenville Formation is also host to a large number of auriferous vein-quartz deposits associated with intense silica, sericite, carbonate and pyrrhotite alteration (O'Reilly *et al.*, 1992).

Many of these deposits share an association with shear zones or secondary structures related to shear zones (e.g. Kontak *et al.*, 1995; O'Reilly, 1995). During the past summer we delineated several new shear zones and extended many of the previously recognized ones (c.f. Ham and MacDonald, 1994). Two of the most notable are the Napier River fault (Horne and White, 2000) and the Kemptville shear zone (O'Reilly, 1995). The Napier River fault is poorly exposed; however, a prominent, northeast-trending linear is recognized that crosses the contact between the Goldenville Formation and South Mountain Batholith contact (Fig. 2 and 8). This zone is characterized by brecciation, intense silicification and epithermal textures similar to those described in the Tobeatic Fault Zone by Corey and Horne (1989). Preliminary assay results indicate elevated zinc levels. Several gold occurrences lie within the Kemptville shear zone (Fig. 2). Although some shear zones in the map area are known to be directly associated with mineral deposits, many have not been fully evaluated and provide excellent targets for future exploration.

Summary

The stratigraphy and map units defined in the map areas to the north (White *et al.*, 1999; Horne *et al.*, 2000) can be traced into the present map area. The distribution of units is controlled by the Black Point anticline and the Bear Cove synclinorium (Culshaw and Leisa, 1997). Although the White Rock Formation in the Yarmouth area may have originally been folded into a syncline, the formation now appears to young to the east, with no obvious repetition of units, calling into question the presence of a syncline. The distribution of units in the White Rock Formation is more likely due to regional scale shear zones. The occurrence of a distinctive, trace fossil-rich, magnetite-bearing metasiltstone unit may provide a useful marker horizon in the Goldenville Formation.

Regional folds are northeast-trending, generally plunge gently to the southwest, and have a well developed axial planar cleavage. Although the area is cut by numerous unit-parallel Middle Carboniferous shear zones, the most significant is the Chebogue Point shear zone which juxtaposes biotite- and chlorite-zone rocks of the Meguma Group with staurolite-zone rocks of the White Rock Formation.

Acknowledgments

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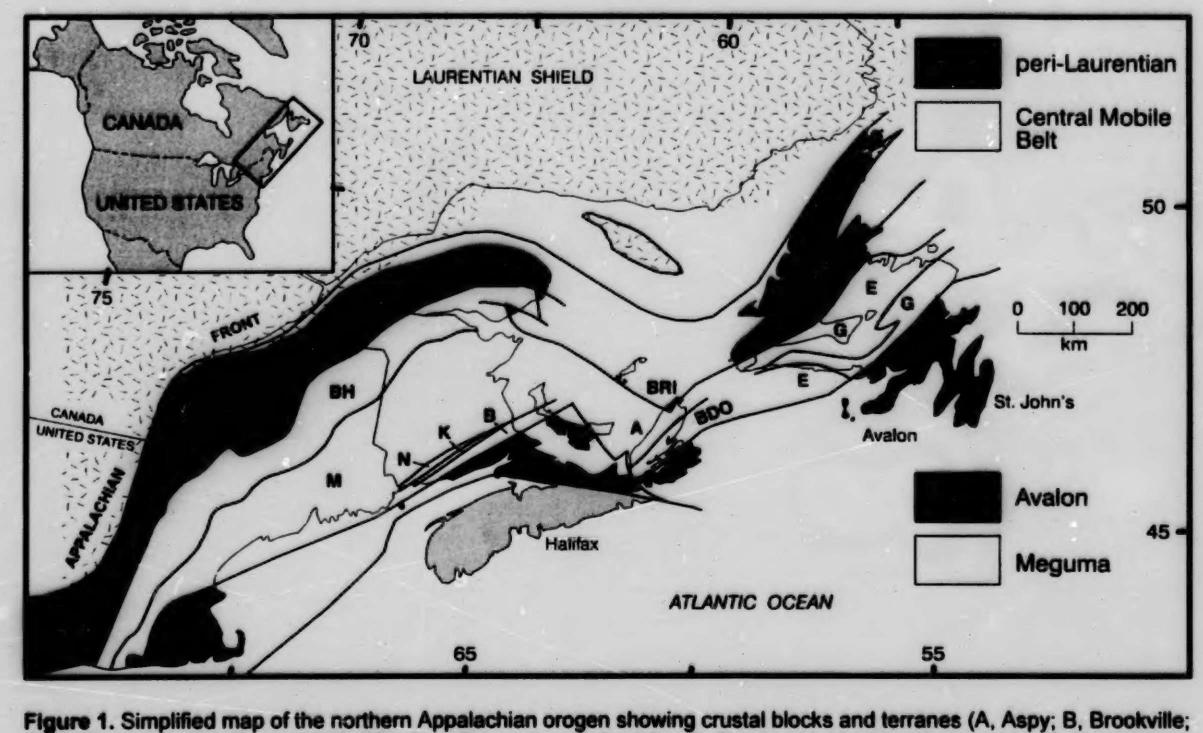
New Evidence for Distinction Among Laurentian Fragments and Avalonian and non-Avalonian Terranes in the Northern Appalachian Orogen[1]

S. M. Barr[2], R. P. Raeside[2], C. E. White and B. V. Miller[3]

More than a decade of stimulating controversy has followed from the proposal (Barr and Raeside, 1989; Barr and White, 1989) that the classical Avalon zone in the northern Appalachian orogen contains terranes that are distinct from the Avalon terrane *sensu stricto*. The disagreements have focused mainly on (i) whether Grenvillian basement rocks of the Blair River inlier in Cape Breton Island are part of the Laurentian Grenville Province, and (ii) the relationship between Late Neoproterozoic elements within the "Central Mobile belt" and the Avalon terrane.

We present a more detailed interpretation of terranes in Atlantic Canada that incorporates recent new field, petrochemical, and chronological data from southern New Brunswick and northern Cape Breton Island. These new data enable us to extend the detailed terrane correlations made previously between Newfoundland and Cape Breton Island (Barr *et al.*, 1998) through southern New Brunswick (Fig. 1). The interpretation is compatible with some recent models (e.g., Van Staal *et al.*, 1998) but differs significantly from other recently published interpretations (e.g., Hall *et al.*, 1998; Williams *et al.*, 1999).


70
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APPALACHIAN
Avalon
Halifax
45
Meguma
ATLANTIC OCEAN
65
55

Figure 1. Simplified map of the northern Appalachian orogen showing crustal blocks and terranes (A, Aspy; B, Brookville; BDO, Bras d'Or; BH, Bronson Hill; BRI, Blair River inlier; E, Exploits; G, Gander; H, Humber; K, Kingston; M, Miramichi; N, New River; ND, Notre Dame).

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Petrochemical, geochronologic, and isotopic data have without exception supported a Laurentian Grenvillian affinity for the Blair River inlier in northern Cape Breton Island (Fig. 1). Like the Humber zone of western Newfoundland, the inlier was affected by Silurian plutonism and amphibolite facies metamorphism. New U-Pb data from meta-gabbro dykes in the Blair River inlier indicate Late Neoproterozoic igneous crystallization ages like those of the Long Range dykes in western Newfoundland, interpreted to reflect rifting during the birth of the Iapetus Ocean. The new data further support correlation between the Blair River inlier and similar basement inliers in western Newfoundland.

Inconsistent interpretations continue to be presented for components of the "Central Mobile belt" (Fig. 1), in part because the complexity of geological components is still being unravelled. Isotopic data show that Neoproterozoic rocks of the "Central Mobile belt" in the Bras d'Or, Brookville, and New River terranes in Cape Breton Island and New Brunswick are distinct from those of the Avalon terrane *sensu stricto.* These rocks are interpreted to represent peri-Gondwanan terranes that form the basement for Lower Paleozoic rocks of the Gander and Exploits terranes of the Central Mobile belt. Similar Neoproterozoic "basement" rocks exposed in southern and central Newfoundland have been inaccurately included in "Avalon". The presence within the Central Mobile belt of Silurian arc-type volcanic-plutonic belts such as the Kingston terrane in southern New Brunswick (Barr *et al.,* 1999; Fyffe *et al.,* 1999) and the Belle Cote Road orthogneiss in Cape Breton Island (Price *et al.,* 1999) indicates that some of these elements represent separate peri-Gondwanan terranes subsequently amalgamated by subduction-collision events and modified by transcurrent movements. They are located inboard of the Avalon terrane *sensu stricto.*

In contrast, the Meguma terrane (Fig. 1) is located outboard of the Avalon terrane, but may also have been the site of Silurian subduction and subsequent terrane amalgamation (Acadian orogeny). It seems clear that Iapetus was not the only ocean that closed during the Paleozoic tectonic evolution of Atlantic Canada.

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Biographical Note

Robert Raeside graduated from the University of Calgary in 1982 with a Ph.D. in metamorphic and structural geology. He has been teaching in the Department of Geology at Acadia University since 1982, and has been department head since 1995.

Geology of the Lower to Middle Paleozoic Metamorphic Rocks in the Digby-Weymouth Area, Southwestern Nova Scotia[1]

R. J. Horne, C. E. White, C. Muir[2] and M. Young[2]

Systematic regional (1:10 000 scale) mapping of lower to middle Paleozoic metamorphic rocks, including the Meguma Group (Goldenville and Halifax formations), White Rock Formation and Torbrook Formation, was conducted in the Digby-Weymouth area. Results indicate significant revisions to previous maps, including subdivision and re-assignment of stratigraphy, re-interpretation of regional fold geometries, recognition of a regional-scale shear zone, and identification of new mineral occurrences.

The Goldenville Formation consists of medium- to thickly-bedded metasandstone with variable amounts of laminated metasiltstone. Coarse metasandstone to fine metaconglometate beds occur locally. Concretions, locally metamorphosed to calc-silicate, are abundant within the metasandstone beds. The Halifax Formation conformably overlies the Goldenville Formation and has been subdivided into four lithologic units (members). The Bloomfield member, the lowest unit, consists of distinct green and maroon, locally variegated, laminated metasiltstone. The Acacia Brook member, overlying the Bloomfield unit in the northern part of the area, consists of medium- to dark-grey, well laminated, slate-metasiltstone. The Cunard member consists of dark, finely laminated, locally sulphide-rich, slate and minor metasandstone, and overlies the Bloomfield member in the southern part of the area. The Bear River member (Tremadocian), represents the upper Halifax Formation in the Bear River area and consists of silty slate, metasiltstone and minor metasandstone. In the south part of the area the upper Halifax Formation is referred to as the Sissiboo member, and consists of well laminated and distinctly colour-banded slate-metasiltstone. The White Rock Formation (Silurian), consisting mainly of dark slate with minor metasiltstone, marly metasiltstone and local, thickly bedded quartzite, conformably to disconformably overlies the Halifax Formation. The Torbrook Formation (Early Devonian) conformably overlies the White Rock Formation and consists of slate and metasiltstone, locally with abundant macrofossils.

The lower to middle Paleozoic metamorphic sequence is folded into regional-scale northeast-southwest to north-south, moderately plunging folds. Axial planar cleavage is strongly developed in the Goldenville and Halifax formations, however, only moderately developed in the White Rock and Torbrook formations. The variation in strain may be related to the disconformity between the Halifax and White Rock formations. Concretion shapes and stretched clasts in coarse metasandstone and conglomerate of the Goldenville Formation indicate significant extension parallel to fold hinges. Regional metamorphism is greenschist facies (up to biotite). Contact metamorphism is defined by biotite ±cordierite±andalusite hornfels adjacent to granite intrusions and locally in areas away from exposed intrusions, implying buried intrusions in these areas. A regional-scale, dextral shear zone reflecting Carboniferous reworking of the fold belt overlaps the Goldenville-Halifax boundary and several late brittle faults occur.

Several new mineral occurrences were found, including Cu-Mo in quartz veins associated with the Clayton Hill pluton and Cu-Sn-Ag-Zn associated with skarn developed from concretions in the Goldenville Formation in areas of contact metamorphism.

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Application of Combined Enhanced Aeromagnetic and Digital Elevation Data in the Geological Interpretation of the Eastern Meguma Terrane of Nova Scotia[1]

M. S. King[2] and R. J. Horne

Aeromagnetic and digital elevation data are useful for regional geological interpretation. Combination of these data can further enhance geological features, allowing for interpretation beyond that of the individual data sets. Enhanced aeromagnetic data, consisting of calculated second vertical derivative data, have been overlain on a detailed digital elevation model (DEM), generated from 1:10 000 scale topographic information, to create a single map image for the eastern Meguma Terrane. The aeromagnetic data were gridded to 75 m and the digital elevation data were gridded to 40 m. Colour contour information was generated from the magnetic data, whereas the digital elevation data are presented as shaded relief.

These combined data sets reveal useful and interesting features that enhance geological interpretation of the eastern Meguma Terrane, locally revealing previously unrecognized features. For example, the combined data indicate a more complex, composite nature for northwest-trending faults than is obvious from the offset of aeromagnetic data alone. In addition, the DEM illustrates the presence of countless, parallel, northwest-trending linear features, resulting in a penetrative fabric at 1:250 000 scale. Several previously undocumented, regional-scale northeast-trending linear features are defined by the DEM. These linear features are locally coincident with abrupt changes in aeromagnetic data or geological contacts, implying that they represent faults. In the Carboniferous Musquodoboit Basin, these northeast-trending linear features locally correspond to mapped basin margins. In one area, significant attenuation of the aeromagnetic response from the underlying Meguma Group, resulting from overlying Carboniferous strata, is bounded by two northeast-trending features. This implies that these structures may influence basin geometry. Attenuation of the magnetic signal within this block indicates significant vertical displacement associated with an increase in the thickness of non-magnetic (e.g. Carboniferous) strata. Locally, linear features in the DEM define bedding-parallel ridges in the Meguma Group, providing detailed structural information for folds in areas with little or no magnetic relief. Aeromagnetic and (or) DEM data have distinct patterns over areas of known intrusions (e.g. Musquodoboit Batholith) that can be useful in defining pluton boundaries in areas with little geological control. Linear features defined in the DEM cut plutons or are coincident with the pluton boundaries, constraining the relative age of these faults. The combination of aeromagnetic and DEM data are a useful tool in interpreting the bedrock geology in the Eastern Meguma Terrane.

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Stratigraphy, Geochemistry and Age of the White Rock Formation in the Yarmouth area, Nova Scotia[1]

L. A. MacDonald[2], S. M. Barr[2], C. E. White and J. W. F. Ketchum[3]

The White Rock Formation in the Yarmouth area occurs in a faulted synclinal structure underlain by slate and phyllite of the Halifax Formation. The formation is divided into 7 stratigraphic units based on field mapping, petrographic study and published geophysical maps. The stratigraphically lowest unit consists of mainly metapelitic rocks that are schistose on the eastern limb near the faulted contact with the Brenton Pluton. The unit grades into a quartzite unit which becomes fine-grained near the top. The third unit consists of metavolcanic and metasedimentary rocks near the base and mafic metavolcanic rocks in the upper part. On the eastern limb, the upper metavolcanic rocks are felsic. Unit four is a sequence of mafic metavolcanic and metasedimentary rocks which include conglomerate near the top. The fifth unit is a predominantly mafic metavolcanic unit with minor metasedimetary rocks. Metavolcanic rocks include pillow basalt and towards the top, felsic and intermediate tuffaceous rocks (including ignimbrite). The sixth unit consists of intermediate and mafic metavolcanic rocks (with pillows) with minor metasedimentary rocks, grading upwards into slate near the top. The stratigraphically highest unit preserved in the syncline is predominantly mafic tuff and flows. All units are commonly intruded by mafic dykes and/or sills which also occur in the adjacent Halifax Formation. Metamorphic grade increases from greenschist facies in the south to amphibolite facies in the north.

The Brenton Pluton occurs on the eastern limb of the syncline and appears to be in faulted contact with unit 1 of the White Rock Formation on the west and slate of the Halifax Formation on the east.

Mafic volcanic rocks of the White Rock Formation have chemical features indicating alkalic affinity and within-plate tectonic setting. The felsic volcanic rocks are chemically similar to the Brenton Pluton and both have characteristics of within-plate A-type granites. Preliminary results of U-Pb dating of zircon from ignimbrite in unit 5 yields an age of 438 +31/-35 Ma, supporting the Silurian age of the White Rock Formation based on fossil evidence from the formation elsewhere in southern Nova Scotia.

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A Forensic Petrological Study of Granite Blocks from the Sambro Lighthouse[1]

Michael A. MacDonald and Alan Ruffman[2]

The Sambro Island Lighthouse was built in 1758-60 and is the oldest operating lighthouse in North America. The lighthouse was the focus of a major restoration program by the Canadian Coast Guard in 1998. The lower part (13.1 m) of the lighthouse, representing the original construction, was built with granite blocks of uncertain origin. Several sources for these blocks have been postulated, including: ballast from a vessel from Massachusetts; one of the five granite quarries on early geological maps of the Halifax area (Faribault, 1907, 1908); a quarry in the Duncan's Cove-Chebucto Head area; or possibly from Sambro Island itself. Another suggestion was that the granite blocks were salvaged from the fortress of Louisbourg after the defeat of the French army; however, Louisbourg was constructed from sandstone and is not a possible source. In 1998, the authors began a forensic petrological study of the granite blocks to establish their origin with field assistance from the Nova Scotia Lighthouse Preservation Society.

Granitic rocks of the Halifax area were studied extensively in 1985, as part of a mapping project under the 1984-1989 Canada-Nova Scotia Mineral Development Agreement. Specifically, work included 1:10 000 scale geological mapping, whole-rock geochemical analysis, and mineral chemistry studies to establish compositional variations within the granitic rocks. The database generated during this study provides an excellent framework for forensic petrological work on the Sambro Lighthouse granite blocks.

Three chips were collected from separate granite blocks in the Sambro Lighthouse along with a large representative sample of granitic outcrop on the island and representative samples from coastal exposures between Sambro and Chebucto Head. Petrographic inspection and microprobe analysis of biotite grains from these samples were compared to data from the major granitic rock types of the Halifax Pluton. The petrographic work reveals that the Sambro Lighthouse granitic blocks show mineralogical features consistent with some granitic rocks of the Halifax Pluton. Consequently, these blocks: (1) are not considered to have originated as ship ballast from New England; (2) were not quarried from the biotite monzogranite on Sambro Island; (3) do not resemble fine- or coarse-grained leucomonzogranite of the Halifax Pluton and, therefore, did not originate from the Brookfield quarry on Terrence Bay; and (4) were probably quarried from either the Harrietsfield or Sandy Lake monzogranite units. The exact location of the quarry site has not yet been confirmed; however, the forensic petrology supports the documented quarry in the Chebucto Head area as a possible source for the Sambro Lighthouse granite.

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[1] Atlantic Geoscience Society Colloquium and Annual General Meeting, Fredericton, New Brunswick, February 11-12, 2000.

[2] Geomarine Associates Ltd., P. O. Box 41, Stn. 'M', Halifax, Nova Scotia, Canada B3J 2L4.

Evidence for a ~13 ka Glacier Advance in Atlantic Canada[1]

Rudolph R. Stea

Was there a significant late-glacial advance correlative with the Port Huron event of the mid continent in Atlantic Canada? Data from Nova Scotia and the offshore supports the idea of an ice advance that occurred approximately 13 ka.

The Appalachian Ice Complex was a series of Wisconsinan ice centres, spatially and temporally distinct, that advanced and retreated producing a palimpsest of erosional and depositional glacial landforms. Four main phases of ice flow have been recognized, with the youngest event termed the Chignecto Phase. This flow was largely directed into marine bays bordering Nova Scotia, although striae relating to this phase are found on 300 m highland areas near the former ice centres. These southwestward flow patterns can be traced to ice marginal deposits in southwest Nova Scotia, northern Nova Scotia and the inner Scotian Shelf. Ages of the ice margins were established by direct dating of a glaciomarine delta and by bracketing ages through AMS dating of lake sediment cores beyond and behind the margins. The timing of deglaciation was established using a linear regression model of AMS ages vs depth of organic gyttja beneath a distinctive Younger Dryas marker horizon.

The average basal accumulation age of four lakes behind the onshore Chignecto Phase margins is 11.6 ka, whereas five lakes beyond the margin averaged 12.9 ka . Three shell fragments from a glaciomarine delta beyond the margin averaged 13.5 ka. The minimum age can be significantly increased by considering a deglaciation age of 12 ka from buried peat at the head of the Bay of Fundy, and adding 200 varve years of glacial lake sediment that pre-dated the peat formation. The best estimate of the age of this margin would be between 12.2 and 13.0 ka. On the inner Scotian Shelf the age of the Chignecto Phase margin was bracketed between 12.7 and 14 ka, based on sequence stratigraphy, age dates, and foraminiferal assemblages of a proglacial glaciomarine section. Combining both areas, a reasonable estimate for the time of formation of the Chignecto Phase margin is between 12.7 and 13 ka.

What caused the Chignecto Phase? Drawdown may only be part of the answer as the Chignecto Phase centres were located at or near ice streams of the previous Scotian Phase. Studies off the Scotian Slope have revealed a significant cooling and ice rafting event ca. 13 ka which may have resulted from renewed ice stream activity in the Gulf of St. Lawrence. It is possible that this event fits into a 1500 year millennial oscillation cycle, defined by Bond (1997), in which the next major event was the Younger Dryas.

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[1] Presented at the Canadian Quaternary Association Annual Meeting, Calgary, Alberta

Evidence of the Younger Dryas re-advance of a Gulf of St. Lawrence glacier from the "Great Ditch" of Nova Scotia[1]

Rudolph R. Stea and Robert J. Mott[2]

In the summer of 1999, the Maritimes and Northeast Pipeline Company excavated a 3 m deep trench across northern Nova Scotia bordering the Gulf of St. Lawrence to host the Sable Island gas pipeline. The "great ditch" of Nova Scotia exposed a continuous transect of surficial deposits along a 237 km corridor. A paleosol with preserved A horizon (peat and wood) was found buried under 2-10m of surface till over a wide area of the pipeline route. 10 new sites were sampled and submitted for palynological analysis and radiocarbon dating. The A horizon peaty layer throughout the region is only a few cm thick consisting mainly of herbaceous plant material with few large wood fragments. It is relatively flat and dips under the trench while the trench follows the gently undulating, fluted glacial topography. Till fabric analysis in the upper reddish diamicton, indicated a strong fabric parallel to regional glacial lineations. Radiocarbon dates on wood from 2 sites were 10.9 ka (GSC-6435) and 10.8 ka (GSC-6419).

Previous to these finds only two localities revealed till overlying peat, so the extent of YD glaciers could not be clearly established. The regional till sheet overlying the soil can be traced to ice-marginal deposits near the Cobequid Highlands to the south, including ice-dammed glaciolacustrine sediments overlying peat found along the coasts of northern Nova Scotia and Cape Breton. Stea and Mott (GPQ-1998) had proposed a glacier around eastern PEI to account for the formation of these ice marginal glacial lakes. These discoveries have suggested a greater YD ice cover than formerly envisioned based on the few lakes in this region that have preserved a pre-Younger Dryas sedimentary record. These must have been spared from glacial erosion.

Please view our website for photos and a description of the trench discoveries. (http://www.gov.ns.ca/natr/meb/field/start.htm).

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[1] Presented at the Association de Quebec Quaternaire, Montreal, Quebec, May 2000

[2] Geological Survey of Canada, 601 Booth Street, Ottawa, Ontario, Canada K1A 0E8

Using Whole Rock Geochemistry to Locate the Source of Igneous Erratics from Drumlins on the Atlantic Coast of Nova Scotia[1]

Rudolph R. Stea and Georgia Pe-Piper[2]

Whole rock geochemistry has been determined for erratics from the surface Lawrencetown Till in two drumlins on the Atlantic coast of Nova Scotia. The geochemical data, particularly trace element composition, allows source rocks to be identified more precisely than by visual identification or petrographic microscopy. A drumlin near Lunenburg contains erratics of Neoproterozoic arc-related plutonic rocks and basalts that outcrop only in a small area near Parrsboro in the Cobequid Highlands. Some associated erratics of granite precisely match a small late Devonian pluton in the same area and other granites and rhyolite could also be derived from late Devonian rocks in the same area. The type section of the Lawrencetown Till contains different Neoproterozoic plutonic rocks of a type found in the eastern Cobequid Highlands, together with a distinctive late Devonian granite with sodic amphiboles that is restricted to a small area near the Debert River. Both these source areas indicate a southward flow of ice (Escuminac Phase) from an ice centre in the vicinity of Prince Edward Island (Escuminac Ice Centre) which deposited the Lawrencetown Till from fast-flowing ice streams that terminated at the edge of the continental shelf. Earlier southeastward-flowing ice (Caledonia Phase) deposited the Hartlen Till that forms the core of the drumlin. Drumlins in Nova Scotia are complex palimpsest landforms which formed by till-accretion, and evolved in surface form throughout multiple flow events.

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[1] Presented at the Atlantic Geoscience Society Annual Colloquium, Fredericton, New Brunswick, February 2000

[2] Department of Geology, Saint Mary's University, Halifax, Nova Scotia, Canada B3H 3C3

Bedrock Geology of the Southwestern Meguma Terrane, Nova Scotia[1]

C. E. White, R. J. Horne, M. S. King, L. A. MacDonald[2], S. M. Barr[2], C. Muir[3], P. H. Reynolds[3] and J. W. F. Ketchum[4]

Department of Geology, Introduction

Detailed bedrock mapping in the southwestern Meguma terrane of Nova Scotia, from Digby to Shelburne (Fig. 1), is part of a five year program initiated in 1998 by the Nova Scotia Department of Natural Resources. The principal goals of the project are to produce a series of 1:50,000 scale geological maps of the area, to describe and interpret the sedimentary, igneous, metamorphic, and deformational history, and evaluate the economic potential. We report here preliminary results from the first two years of the project.

Map Units

The *Goldenville Formation* consists mainly of grey, massive to locally laminated or cross-laminated metasandstone and interbedded metasiltstone and slate, with minor coarse-grained metasandstone and conglomerate. Carbonate and manganese concretions are common in metasandstone beds. Rare trace fossils have been observed, but not assigned an age. ^{40}Ar/^{39}Ar ages from detrital single and multigrain muscovite samples from the Digby area yield an average age of ca 550 Ma, in agreement with previously obtained U-Pb dates from detrital zircon and titanite (Krogh and Keppie, 1990) and ^{40}Ar/^{39}Ar muscovite ages (e.g. Hicks *et al.*, 1999) obtained elsewhere in the Goldenville Formation.

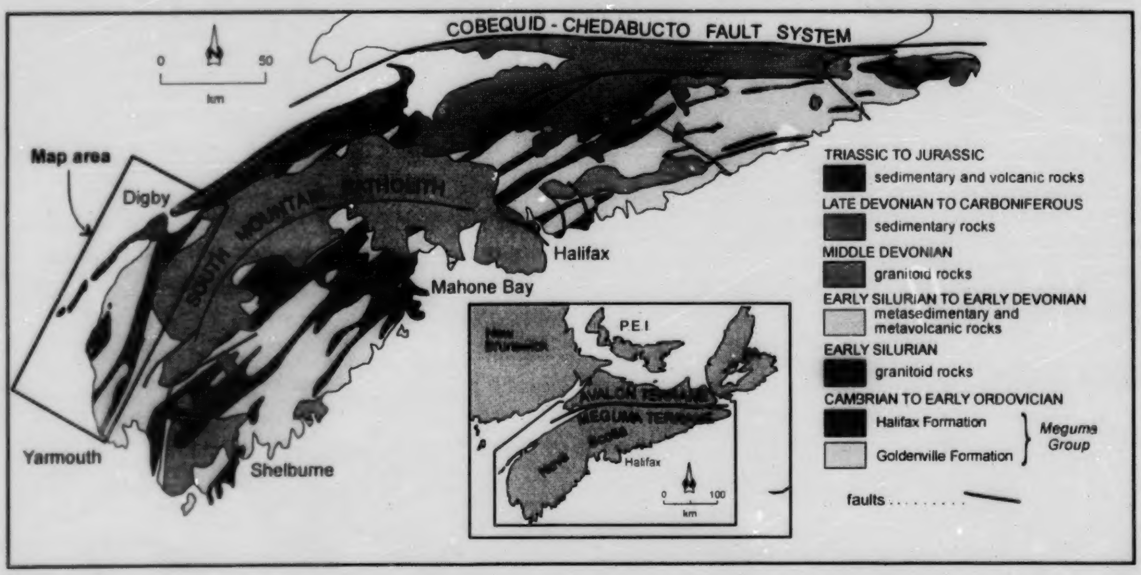
COBEQUID - CHEDABUCTO FAULT SYSTEM
0
50
km
Map area
Digby
SOUTH MOUNTAIN BATHOLITH
Halifax
Mahone Bay
Yarmouth
Shelburne
P.E.I
AVALON TERRANE
MEGUMA TERRANE
Halifax
0
100
km
TRIASSIC TO JURASSIC
sedimentary and volcanic rocks
LATE DEVONIAN TO CARBONIFEROUS
sedimentary rocks
MIDDLE DEVONIAN
granitoid rocks
EARLY SILURIAN TO EARLY DEVONIAN
metasedimentary and metavolcanic rocks
EARLY SILURIAN
granitoid rocks
CAMBRIAN TO EARLY ORDOVICIAN
Halifax Formation
Goldenville Formation
Meguma Group
faults

Fig. 1. Geological map of the Meguma terrane, Nova Scotia, showing the location of the map area.

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[1] Extended abstract accepted for poster presentation at GeoCanada 2000 GAC/MAC Annual Meeting May 29-June 2, 2000

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The overlying *Halifax Formation* has been divided into several informally defined members. The basal Bloomfield member consists of distinctly banded maroon and green, locally mottled metasiltstone to slate with minor calc-silicate nodules. This unit is stratigraphically and structurally conformable with the underlying Goldenville Formation and in places appears gradational. The strata overlying the Bloomfield member are divided into the (i) Acacia Brook member in the northeastern part of the mapped area, characterized by light-to dark grey, planar laminated slate with minor metasiltstone and metasandstone, and (ii) Cunard member to the southwest, consisting of dark grey to black, sulphide-rich slate and metasiltstone. The Acacia Brook and Cunard members may be facies equivalent on the basis of their stratigraphic position immediately above the Bloomfield member. However, The Acacia Brook member contains characteristics that are more similar to the Bloomfield member and the Acacia Brook formation may "pinch-out" to the southwest. The Bear River member is the uppermost unit of the Halifax Formation in the northeastern part of the mapped area and consists of light- to dark colored, silty slate with minor metasiltstone, slate, and metasandstone. Along strike to the southwest this member is interpreted to interdigitate with the Sissaboo River member which contains thinly laminated green-grey metasiltstone and slate. Thin crossbedded metasandstone lenses are characteristic of both members. Fossil occurrences are generally sparse, although trace fossils are abundant. Early Tremadoc acritarch microfossils were reported by Doyle (1979) and Early Tremadoc specimens of the graptolite *Rhapdinopora flabelliforme* have been recovered near the top of the Bear River member (White *et al.*, 1999). A ^{40}Ar/^{39}Ar age obtained from detrital muscovite sample yielded an apparent age of ca. 596 Ma.

The *White Rock Formation* is well exposed in the Digby and Yarmouth areas. The contact with the underlying Halifax Formation in the Yarmouth area is faulted; however, in the Digby area the contact is a disconformity or angular unconformity. In the Digby area the White Rock formation consists of grey to dark grey slate and metasiltstone with minor light grey metasandstone. Calc-silicate lenses are common. A characteristic feature of this formation is a thick (up to 30 m), laminated and cross-stratified metasandstone layer. Primary sedimentary structures are common and upper Silurian vertebrate and crinoid remains have been collected near the top of the formation (Bouyx *et al.*, 1997). Single and multigrain detrital ^{40}Ar/^{39}Ar muscovite ages range from ca. 550 to 440 Ma. In the Yarmouth area, the White Rock Formation has been divided into 7 stratigraphic units composed of predominantly metavolcanic rocks with mafic to felsic lithic and crystal tuff interlayered with mafic flows, metasiltstone and metasandstone. Associated with the metavolcanic rocks is the fault-bounded granitic Brenton Pluton. Mafic volcanic rocks of the White Rock Formation have chemical features indicating alkalic affinity and within-plate tectonic setting. The felsic volcanic rocks are chemically similar to the Brenton Pluton and both have some characteristics of within-plate A-type granites. U-Pb dating (zircon) from a felsic unit yields a preliminary age of 438 +31/-35 Ma, supporting the Silurian age of the White Rock Formation based on fossil evidence from elsewhere in the formation and similar to the detrital muscovite age.

The *Torbrook Formation* conformably overlies the White Rock Formation in the Digby area and consists of poorly cleaved, grey metasiltstone and calcareous metasiltstone with minor slate, metasandstone, marble, and rare ironstone. Primary sedimentary structures and Early Devonian (Lochkovian to Lower Emsian) shelly fossils are common (e.g. Bouyx *et al.*, 1997).

Numerous mafic sills intrude all above units and have been divided into two suites based on field relations. The older suite is restricted to the Halifax Formation and appears to have been emplaced during deposition of the formation. A younger suite occurs in the Halifax, White Rock and Torbrook formations. Both types of sills were previously interpreted to be tholeiitic transitional to alkalic and were emplaced in a continental, within-plate tectonic setting (Barr *et al.*, 1983). However, additional geochemical studies are in progress to confirm the older data.

Devonian granitoid units in the mapped area consist of the ca 370 Ma South Mountain Batholith and Ellison Lake and Clayton Hill plutons. They consist of medium- to coarse-grained monzogranite and granodiorite with megacrysts of K-feldspar. These intrusions produced well developed contact metamorphic aureoles with abundant andalusite and cordierite that are superimposed on regional fabrics.

The *Wolfville Formation* unconformably overlies the Meguma Group and South Mountain Batholith. It consists of Middle to Late Triassic red, coarse-grained sandstone and conglomerate with minor red-brown siltstone and shale. The *Blomidon Formation* conformably overlies the Wolfville Formation and consists of red-brown to grey-green siltstone and minor sandstone and shale. Palynomorph assemblages indicate a mainly Late Triassic age, with the very top of the formation extending into the Jurassic (Wade *et al.*, 1996). The *North Mountain* Formation conformably overlies the Blomidon Formation and consists of a succession of basaltic flows dated at ca 202 Ma (U-Pb zircon; Hodych and Dunning, 1992).

Deformation and Metamorphism

The lower to middle Paleozoic rocks and mafic sills were deformed into regional northeast- to north-northeast-trending, moderately plunging folds with axial planar cleavage during the Devonian Acadian Orogeny. However, the White Rock and Torbrook formations are exposed in a regionally continuous syncline that extends throughout the mapped area and in the northeast these rocks are typically poorly cleaved or lack cleavage. Regional metamorphism associated with the Acadian Orogeny was at greenschist facies conditions for the majority of the mapped area with a peak metamorphic mineral assemblage of muscovite + chlorite + albite in the pelitic rocks. In the southwest, metamorphic grade locally reached amphibolite facies with a peak metamorphic mineral assemblage of biotite + garnet + staurolite + cordierite + andalusite in the pelitic rocks. $^{40}Ar/^{39}Ar$ muscovite and whole rock data indicate that deformation and metamorphism associated with the Acadian Orogeny was at ca 400 Ma (e.g. Hicks *et al.*, 1999; this study).

The intrusion of the ca 370 Ma South Mountain Batholith and Ellison Lake and Clayton Hill plutons produced well-developed contact metamorphic aureoles that are superimposed on regional fabrics. Close to the plutons cordierite and andalusite are abundant. A $^{40}Ar/^{39}Ar$ whole-rock age of ca 370 Ma from the Torbrook Formation likely reflects thermal overprint by the adjacent South Mountain Batholith.

Major Middle Carboniferous (ca. 320 Ma) deformation, characterized by southeast-dipping shear zones and northwest verging folds, overprint the Acadian folds in the southwestern part of the mapped area (Culshaw and Liesa, 1997). One shear zone has been extended northeast to the Digby area where it is defined by a wide zone (locally > 1 km) of shear-related crenulation and minor folds and overlaps the boundary of the Goldenville and Halifax formations. Displacement is mainly northwest-directed dip-slip in the southwest; however, displacement in the northeast is strike-slip.

Discussion and Summary

In this study, the traditional unit names in the Meguma terrane have been used. However, recently it has been suggested that the Meguma Group be elevated to the rank of supergroup, the Goldenville and Halifax formations to group status, and the White Rock and Torbrook formations combined into the Annapolis Supergroup (e.g. Schenk, 1997).

The Halifax Formation in the Digby - Yarmouth area has been subdivided into several discrete members in which the overall stratigraphy is broadly comparable to that documented elsewhere in the Meguma Group (e.g. Schenk, 1997). Subdivisions in the Goldenville Formation were not recognized largely due to the monotonous character of the formation. The Bloomfield member represents the lowermost stratigraphic unit in the Halifax Formation and is overlain by the Acacia Brook and Cunard members. The Bear River member and facies equivalent Sissaboo River member represent the uppermost unit and the presence of early Tremadoc fossils suggests that the Cunard, Acacia Brook and Bloomfield members, together with the Goldenville Formation, are Cambrian in age.

The U-Pb age combined with fossil control indicate that the White Rock Formation is entirely Silurian in age. This suggests a time gap of approximately 60 Ma between the top of the Halifax Formation and the deposition of the White Rock Formation, and supports the presence of an unconformity between the two formations. The Torbrook Formation contains Early Devonian fossils and is in gradational contact with the underlying White Rock Formation.

The $^{40}Ar/^{39}Ar$ data suggest that the ca. 400 Ma Acadian Orogeny occurred immediately after deposition of the Torbrook Formation and was near completion prior to the intrusion of the South Mountain Batholith. The intense crenulation fabrics in the Bloomfield, Acacia Brook and Cunard members clearly define deformation that was after the Acadian Orogeny and can be traced along strike to shear zones defined in the Yarmouth area. This deformation is Middle Carboniferous in age and postulated to be related to strike-slip movement along the terrane-bounding Cobequid-Chedabucto fault system. It may record final docking of the Meguma terrane against North America.

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Biographical Note:

Chris White graduated from Acadia University in 1984 with a B.Sc. Honours degree in Geology and graduated from Dalhousie University with a Ph.D. in Earth Sciences in 1996. He worked as a Postdoctoral Fellow and laboratory instructor at Acadia University. He is presently employed as a Project Geologist with the Nova Scotia Department of Natural Resources.

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Minor Folds and their Relationship to Regional Fold Evolution, Central Meguma Terrane, Nova Scotia[1]

Michael Young[2]*, Richard Horne and Nicholas Culshaw*[2]

The highly anisotropic turbidite sequences of the Meguma Group are folded into upright, noncylindrical, northeast-southwest trending box and chevron folds. Minor folds are well developed in coticule layers in the Beaverbank member, the basal unit of the Halifax Formation in central Nova Scotia. Classical interpretations for the development of minor folds involve layer-parallel shortening predating regional fold development, with minor folds becoming asymmetric as regional folds develop. This interpretation has been used for the origin of buckled bedding-parallel veins in the Meguma Group.

Minor folds in coticule layers display ptygmatic, sinusoidal, box, and chevron fold geometries, and all folds are moderately noncylindrical. Fold geometry is mainly ptygmatic in regional fold hinges whereas minor folds are more open and commonly display a box fold geometry on regional fold limbs. Some minor folds on regional fold limbs are asymmetric, consistent with flexural flow folding, whereas others are symmetric with axial planes and cleavage at high angles to bedding. Folding of coticule layers record significantly more shortening in regional fold hinges than on regional fold limbs. Coticule layers are always folded in regional fold hinges; however, coticule layers are locally non-folded on regional fold limbs. In thin section, outer arc extension is common in folded coticule layers, recording tangential longitudinal strain. Cleavage exhibits a divergent fan pattern around the outer arc reflecting inverse tangential longitudinal strain. Extensional fractures occur along garnet grain boundaries indicating fold initiation postdates garnet formation. Coticule layers display boudinage parallel to regional cleavage which records significant vertical and hinge-parallel extension.

The observed minor fold geometries, in particular box folds, support development during layer-parallel shortening. However, the lack of minor folds in coticule layers on some regional fold limbs, the contrast in the degree of shortening recorded by minor folds in regional fold hinges compared with limbs, and the variation in symmetry of minor folds and associated cleavage on fold limbs suggest minor folds record additional strain during progressive development of regional folds. We suggest the observed features of minor folds can be explained by layer-parallel shortening in the flat segments of early formed regional box folds followed by hinge migration, resulting in redistribution of minor folds, and continued shortening in fold hinges during progressive fold development. This interpretation is consistent with the box and chevron fold character of regional folds; such folds typically initiate with little layer-parallel shortening and involve considerable hinge migration during development.

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[1] Atlantic Geoscience Society Colloquium and Annual General Meeting, Fredericton, New Brunswick, February 10-12, 2000; *in* Program and Abstracts, p. 47.

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Appendix 1

Mining Industry Activity in Nova Scotia, 1999

Mining Industry Expenditures for Exploration, Development, Capital and Repair

Investment by the mining industry in Nova Scotia is monitored by means of annual surveys of all mining companies having operations or activity in the province. Aggregate producers are not included in this survey. The surveys are carried out by the Nova Scotia Department of Natural Resources (DNR) jointly with Natural Resources Canada (Minerals and Metals Sector - Mineral and Mining Statistics Division), and Statistics Canada (Investment and Capital Stock Division). The Mineral Management Division of DNR actively participates in the Annual Survey of Canadian Mineral Exploration Expenditures and the Annual Survey on Exploration Development, Capital and Repair Expenditures.

Preliminary figures indicate exploration expenditures in 1999 were down moderately from 1998 (Table 1.1), as was diamond-drilling. Capital expenditures at existing mines were up significantly in 1999 from 1998, while repair and maintenance expenditures were down significantly. Mine complex development expenditures in 1999 were up from the year before.

Mining Leases

There were three Mining Leases issued in Nova Scotia during 1999. In April, Michael P. Cullen was issued a Special Mining Lease for his coal property at Cottam Settlement, Colchester County. In July, Thorburn Mining Company was issued a Special Mining Lease for its coal property at Coalburn, Pictou County. In December, Brogan Mining Company was issued a Special Mining Lease for its Little Pond coal property in Cape Breton County.

A Mining Lease renewal was also issued to E-Z-EM Canada Inc. for barite at Brookfield, Colchester County.

Mining Permits

The department issued four Mining Permits during the year. Lynx Minerals Inc. was issued a Mining Permit for the extraction of barite at Scotsville, Inverness County, Michael P. Cullen was issued a Mining Permit for his coal project at Cottam Settlement, Colchester County, Thorburn Mining was issued a Mining Permit for its coal property at Coalburn, Pictou County, and Brogan Mining Company was issued a Mining Permit for its surface coal mine at Little Pond, Cape Breton County.

Table 1.1. Mining industry expenditures in 1998 and 1999.

	1998	1999[1]
Mineral Exploration Expenditures	**$4,835,000**	**$3,632,000**
(field plus overhead)[2]		
Exploration diamond-drilling[2]	20 964 m	14 000 m
Exploration drilling - other[1]	879 m	3 000 m
Mine Complex Development Expenditures	**$2,713,000**	**$4,881,000**
(field plus overhead)		
Capital and Repair Expenditures at Mining Establishments		
Capital Expenditures	**$27,604,870**	**$51,455,000**
Repair and Maintenance Expenditures	**$35,415,668**	**$23,271,000**

[1] preliminary
[2] includes deposit appraisal

Production Information from Mines, Quarries and Other Operations

In 1999, the estimated value of Nova Scotia's mineral production, including secondary mineral processing and crude petroleum, totalled $406 million (Fig. 1.1), a decrease of 14% from the year before. Excluding petroleum, the value of Nova Scotia's mineral production totalled $342 million, down 3% from 1998's figure of $352 million. This decrease was due largely to lower outputs of coal. Approximately 2900 persons were employed in Nova Scotia's mineral industry in 1999 (Fig. 1.2), a 21% decrease from the year before (Table 1.2).

Coal sales dropped by approximately 24% in 1999 to 1.6 million tonnes from 1998's figure of 2.1 million tonnes. Production problems plagued the province's largest coal mine, the Cape Breton Development Corporation's Phalen Colliery. On September 13, 1999, the federal Crown Corporation announced it was closing Phalen. The colliery produced almost seventeen million tonnes of coal over its fifteen-year life. The province's only gold mine, Tangier Limited Partnership's Blueberry Hill Mine in Tangier, Halifax County, closed after only a few months of operation, citing poor recoveries.

On a positive note, 1999 was a record year for Nova Scotia gypsum production with 7.9 million tonnes shipped, mainly to wallboard plants along the US Eastern Seaboard. Nova Scotia is Canada's largest gypsum producer accounting for more than 80% of the country's total production. Shipments of cement, barite, peat moss and clay products also increased in 1999 while salt production remained virtually unchanged at 842 000 tonnes. Production of construction aggregates (crushed stone, sand and gravel) in 1999 totalled 10.6 million tonnes, down slightly from the year before.

Although petroleum is included in the overall value of Nova Scotia's mineral production, this appendix focuses on the non-petroleum sectors of the industry. Table 1.2 provides a summary of the value of the province's mineral production and employment levels in 1998 and 1999. Tables 1.3 to 1.6 provide more detailed information on production of different commodities. Site locations are shown on the accompanying maps, Figures 1.4 and 1.5. Production data are for the calendar year 1 January 1999 to 31 December 1999.

Base Metal Mines and Gold Mines

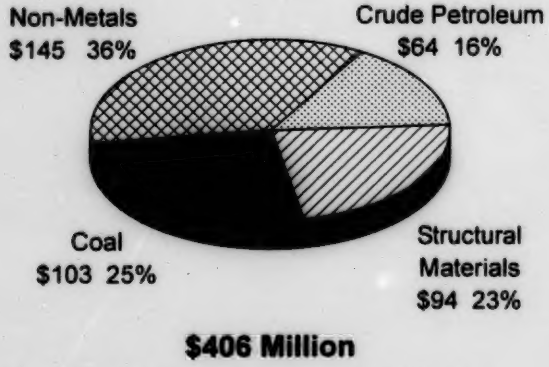
Base Metal Mines

There were no base metal mines in production during 1999.

Gold Mines

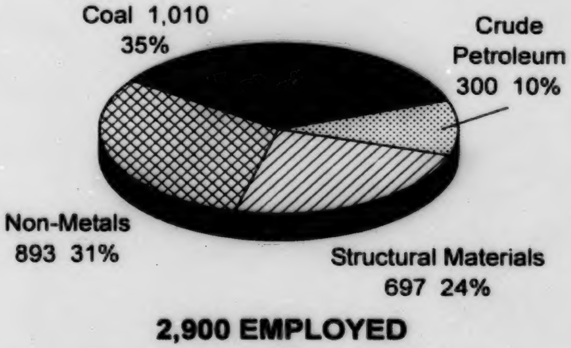
TANGIER LIMITED PARTNERSHIP

Manager: Peter Atkinson, General Manager
Address: P. O. Box 8
Tangier, N. S. B0J 3H0
Production: 63 troy ozs. (1960 grams)
Employees: n/a



Includes secondary mineral processing where applicable
Metal production too small to be expressed at this scale

Figure 1.1. Value of mineral production, in millions of dollars and per cent, by commodity group.



Includes secondary mineral processing employment where applicable
Employment in metal production too small to be expressed at this scale

Figure 1.2. Employment, in numbers of persons and per cent, by mineral commodity group.

Table 1.2. Summary of Nova Scotia mineral production, 1998 and 1999.

DESCRIPTION	1998		1999	
	VALUE ($ thousands[1])	EMPLOYMENT*	VALUE ($ thousands[1])	EMPLOYMENT*
METALS				
Gold	21		24	
Total metals	21	35	24	N/A[2]
INDUSTRIAL MINERALS				
(Non-Metals)				
Anhydrite	1,733		2,018	
Barite	**751		**1,410	
Gypsum	71,703		83,204	
Limestone[3] and Dolomite	2,824		3,619	
Peat	**1,713		**2,035	
Salt	**51,241		**49,891	
Silica	**2,400		2,400	
Total Non-Metals	132,365	872	144,577	893
(Structural Materials)				
Dimension Stone	305		302	
Cement	**35,065		**37,306	
Clay Products	**5,600		**6,000	
Crushed Stone	40,445		39,544	
Sand & Gravel	11,164		10,615	
Total Structural Materials	92,579	654	93,767	697
Total Industrial Minerals	224,944	1,526	238,747	
FUELS				
Coal	127,142	1,790	103,430	1,010
Petroleum - Crude	120,830	340	64,000	300
Total Fuels	247,970	2,130	167,430	1,310
TOTAL MINERAL PRODUCTION	472,935	3,690	406,202	2,900
CHANGE FROM PREVIOUS YEAR	-10%	-3%	-14%	-21%
TOTAL EXCLUDING PETROLEUM	352,105	3,350	342,202	2,600
CHANGE FROM PREVIOUS YEAR	-14%	-3%	-3%	-22%

[1] Estimated from Department of Natural Resources sources

[2] Operator ceased production in January 1999

[3] Does not include the value of limestone quarried for cement production

* Average number of persons during production period

** Processed or manufactured value

Note: Production represents shipments; numbers may not add to totals due to rounding

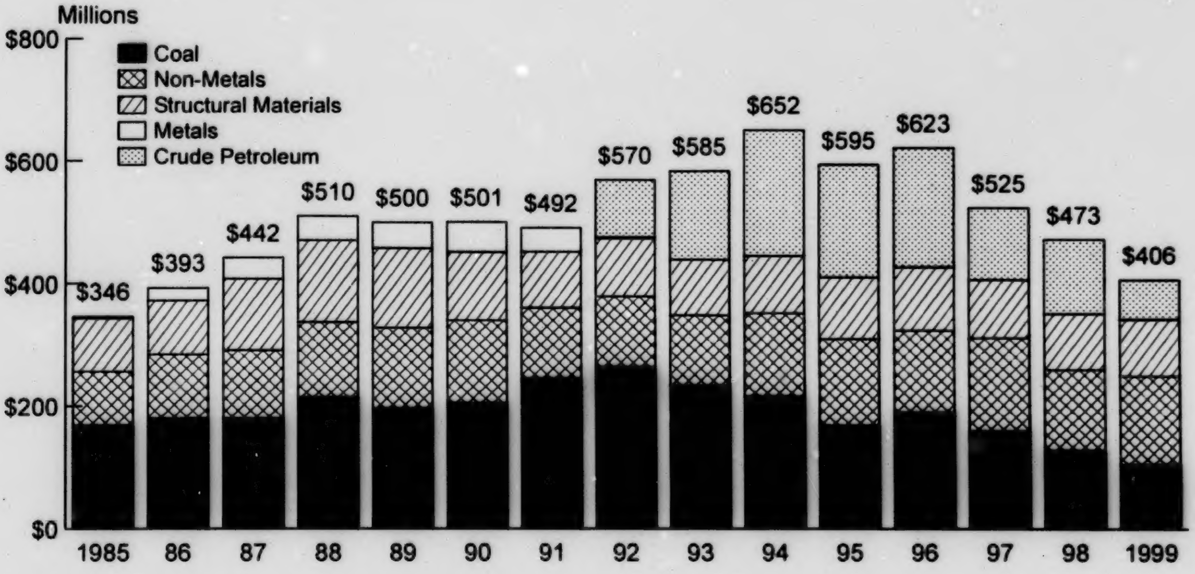
Table 1.3. Coal production for the calendar year 1999.

COMPANY	MINE NAME	LOCATION	PRODUCTION TONS	PRODUCTION TONNES	TOTAL NUMBER EMPLOYED	APPROX. VALUE($)[2]
UNDERGROUND MINING						
Cape Breton Development Corp. (CBDC)	Prince Mine	Point Aconi, Cape Breton County				
	Phalen Mine	Lingan, Cape Breton County				
Total (underground)			1,320,133	1 197 617	860	
SURFACE MINING						
Brogan Mining Company Limited	Little Pond Mines	Alder Point, Cape Breton County	39,819	36 124	18	
Cape Crushing Company Limited	Merritt Point Mine	Alder Point, Cape Breton County	23,649	21 454	2	
Berichan Resources Ltd. (Michael P. Cullen)		Cottam Settlement, Colchester County	19,163	17 385	18	
Evans Coal Mines Limited	St. Rose Mine	St. Rose, Inverness County	55,039	49 931	23	
Hill Reclamation Limited		Springhill, Cumberland County	14,794	13 421	15	
Pioneer Coal Limited	Stellarton Mine	Stellarton, Pictou County	252,262	228 851	36	
Thorburn Mining Limited	Thorburn and Coalburn Mines	Thorburn and Coalburn, Pictou County	37,263	33 805	38	
Total (surface)			442,004	400 983	150	
TOTAL FOR ALL COAL PRODUCERS			1,762,137	1 598 600	1010	103,430,000

[1] personnel employed in clerical, supervisory, etc. positions as well as mining personnel.

[2] estimated from Nova Scotia Department of Natural Resources sources

NOTE: Production represents shipments; numbers may not add to totals due to rounding



Includes secondary mineral processing where applicable

Figure 1.3. Historical trend of the value of mineral production in Nova Scotia, 1985-1999.

Tangier Limited Partnership was forced to suspend production at its Blueberry Hill Mine in Tangier, Halifax County, in early 1999 due to low gold prices and shortfalls in production. The mine subsequently closed and receivers were appointed. During the early part of the year, approximately 900 tonnes of ore were mined from the Whin and Marker veins.

Coal Mining Operations

During 1999, there were two underground coal mines, seven surface coal mines, and one coal recovery project operating in the province. Table 1.3 provides production information for the coal mines. The summaries below give brief details of the underground and surface coal mines operating in Nova Scotia.

Underground Coal Mines

CAPE BRETON DEVELOPMENT CORPORATION

Manager(s):	R. MacDonald, General Manager, Phalen Colliery T. MacNeil, Mine Manager, Prince Colliery
Address:	P. O. Box 2500 Sydney, N. S. B1P 6K9

Raw Coal
Production: 1,263,253 tons (1 146 016 tonnes)
Shipments: 1,320,133 (1 197 617 tonnes)
Employees: 860

The Cape Breton Development Corporation is a federal Crown Corporation that operated two underground coal mines in Cape Breton County during 1999. The Corporation's coal production is supplied to Nova Scotia Power Inc.

Phalen Colliery

Raw Coal
Production: 514,851 tons (467 070 tonnes)

The Phalen Colliery, near New Waterford, Cape Breton County, produced coal intermittently during 1999 and was forced to close in December 1999. Mine development had been curtailed for some time and the mine had been scheduled to close at the end of 2000. The mine used a retreat longwall mining method. During 1999, the mine produced from only one longwall, the No. 8 East longwall panel. Production on this wall was adversely impacted by severe roof falls and resulted in long periods of production downtime. In September 1999, the final roof fall occurred, and the Corporation made the decision to cease production from the mine. Following a three month period to salvage equipment, the main fan was shut down and the portals blocked in December 1999.

Table 1.4. Industiral minerals production for the calendar year 1999.

COMPANY	LOCATION	PRODUCTION TONS	PRODUCTION TONNES	TOTAL NUMBER EMPLOYED[1]	APPROXIMATE VALUE ($)[2]
GYPSUM					
Fundy Gypsum Company	Miller Creek and Wentworth Road, Hants County	1,857,632	1 685 233	166	
Georgia-Pacific Canada, Inc.	Sugar Camp, Inverness County	1,844,017	1 672 881	124	
Little Narrows Gypsum Company	Little Narrows, Victoria County	1,279,595	1 160 841	101	
National Gypsum (Canada) Limited	East Milford, Halifax County	3,753,638	3 405 278	100	
Total (gypsum)		8,734,846	7 924 200	491	83,204,000
ANHYDRITE					
Fundy Gypsum Company	Wentworth Road, Hants County	76,989	69 844	see gypsum	
Little Narrows Gypsum Company	Little Narrows, Victoria County	103,044	93 481	see gypsum	
Total (anhydrite)		180,000	163 300		2,018,000
SALT					
The Canadian Salt Company Limited	Pugwash, Cumberland County	843,375	756 105	210	
Sifto Canada Inc.	Nappan, Cumberland County	84,616	76 763	73	
Total (salt)		927,993	841 870	283	49,891,000[3]
LIMESTONE AND DOLOMITE					
Lafarge Canada Inc.	Brookfield, Colchester County	543,434	493 000	11	
Mosher Limestone Company Limited	Upper Musquodoboit, Halifax County	48555	44 049	17	
Nova Scotia Power Incorporated	Glen Morrison, Cape Breton County	83,444	75 700	10	
Ridge Brokers Limited	Southside Harbour, Antigonish County	5,989	5 433	1	
Scotia Limestone Limited	Kellys Cove, Victoria County	4,669	4 236	1	
Total (limestone and dolomite)		686,090	622 418	40	3,619,000[4]
BARITE					
E-Z-EM Canada Inc.	Brookfield, Colchester County	659	598	16	
Lynx Minerals Inc.	Scotsville, Inverness County	4,840	4 391	10	
Total (barite)		5,499	4 989	26	1,410,000[3]
CLAY					
Shaw Brick (a member of the Shaw Group Limited)	Lantz and Milford, Hants County	18,199	16 510	See clay products Table 1.5	n/a[5]

Table 1.4. Continued.

COMPANY	LOCATION	PRODUCTION TONS	 TONNES	TOTAL NUMBER EMPLOYED[1]	APPROXIMATE VALUE[2] ($)
SHALE					
Shaw Brick (a member of the Shaw Group Limited)	Milford, Hants County New Glasgow, Pictou County	7,800	7 076	See clay products Table 1.5	n/a[5]
Total (clay and shale)		25,999	23 586	See clay products	n/a[5]
SILICA SAND					
Shaw Resources (a member of the Shaw Group Limited)	Nine Mile River, Hants County	53,929	48 924	6	2,400,000[3]
Total (silica sand)		53,929	48 924	6	2,400,000[3]
DIMENSION STONE					
Heritage Memorials Ltd.[2]	Quarry: Nictaux, Annapolis County (granite) Plant: Windsor, Hants County	1,685	1 529	20	
Wallace Quarries Ltd.	Quarry: Wallace, (Sandstone) Cumberland County	262	238	5	
Total (dimension stone)		1,947	1 767	2	302,000[2]
PEAT MOSS					
Annapolis Valley Peat Moss Company[2]	Berwick, Kings County	6,021	5 462	24	
Clare Organic Products Ltd.[2]	Meteghan Station, Digby County	2,924	2 653	20	
McDonald Peat Moss Limited[2]	Kennetcook, Hants County	4,754	4 295	18	
Total (peat moss)		13,680	12 410	44	2,036,000[2,3]
AGGREGATES					
Crushed Stone	Various	8,717,900	7 908 806	391	39,544,000
Sand and Gravel	Various	2,925,200	2 653 800	153	10,615,000
Total (aggregates)		11,643,600	10 563 000	544	50,159,000
TOTAL FOR INDUSTRIAL MINERALS[6]		22,290,100	20 221 000	1,470	195,313,000

[1] total employees: mining, production, clerical, supervisory, etc.
[2] estimate from Nova Scotia Department of Natural Resources sources
[3] processed or manufactured value
[4] does not include the value of Lafarge Canada Inc. production, which value is included in the higher manufactured value (cement)
[5] value included in the higher manufactured valuation (bricks)
[6] excluding secondary mineral manufacturing (Table 1.5)
Note: production represents shipments; numbers may not add to totals due to rounding

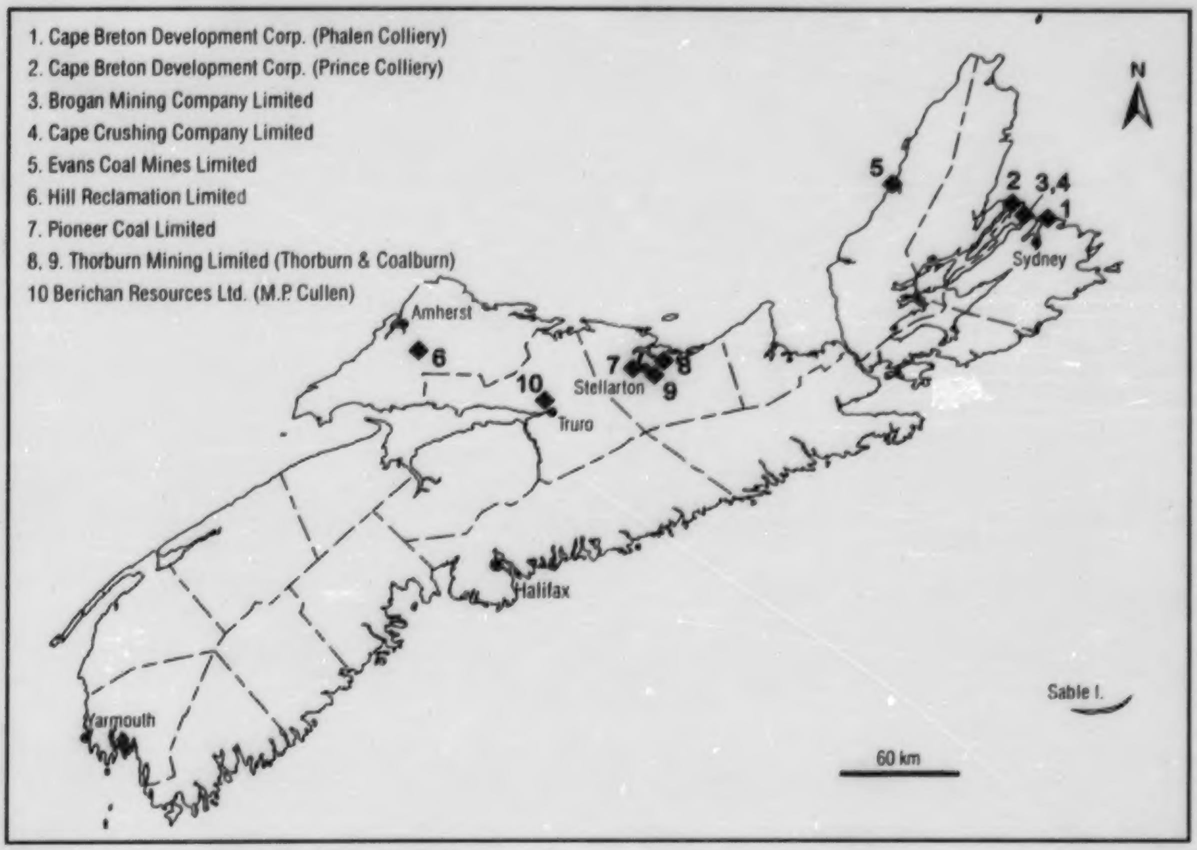

1. Cape Breton Development Corp. (Phalen Colliery)
2. Cape Breton Development Corp. (Prince Colliery)
3. Brogan Mining Company Limited
4. Cape Crushing Company Limited
5. Evans Coal Mines Limited
6. Hill Reclamation Limited
7. Pioneer Coal Limited
8, 9. Thorburn Mining Limited (Thorburn & Coalburn)
10 Berichan Resources Ltd. (M.P. Cullen)
N
5
2
3,4
1
Sydney
Amherst
6
7
8
9
10
Stellarton
Truro
Halifax
Yarmouth
Sable I.
60 km

Figure 1.4. Location of coal mines in Nova Scotia.

Prince Mine

Raw Coal
Production: 748,402 tons (678 946 tonnes)

The Prince Mine is located in Point Aconi, Cape Breton County. The mine began underground production from the Hub Seam in 1975, initially using room and pillar methods. Mechanized retreat longwall operations began in 1980.

During 1999, coal was mined from the No. 9 East longwall panel and development work was completed on the No. 1 North longwall panel. There was a production lag for the last four months of the year after the completion of the No. 9 East longwall before the No. 1 North longwall was ready for production.

Surface Coal Mines

EVANS COAL MINES LIMITED

Manager: E. Fraser
Address: R. R. #1
Inverness, N. S. B0E 1N0
Production: 55,039 tons (49 931 tonnes) of coal
Employees: 23

Evans Coal Mines Limited began surface coal mining operations at St. Rose, Inverness County, in 1993, following the closure of the underground mine in 1992. Coal is extracted from the No. 5 Seam crown pillar and from the pillars left by the underground operation. During the year, mining advanced to the southwest as far as the re-located Duggan Mountain road. Mining was also started in a block of coal to the north of the previously backfilled pit. Overburden and waste rock are removed by blasting and ripping by bulldozers. Material is loaded and hauled using hydraulic excavators and off-road haul trucks.

Production from the Evans mine is trucked to Nova Scotia Power Inc. (NSPI) generating stations, and to Stellarton for blending with other coals, and subsequently supplied to NSPI.

Table 1.5. Secondary mineral manufacturing for the calendar year 1999.

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED[1]	APPROX. VALUE($)[2]
		TONS	TONNES		
CLAY PRODUCTS					
Shaw Brick (a member of the Shaw Group Limited)	Lantz, Hants County	28,000	25 401	43	6,000,000
PORTLAND CEMENT					
Lafarge Canada Inc.	Brookfield, Colchester County	342,683	310 880	79	37,306,000
TOTAL FOR SECONDARY MINERAL MANUFACTURING				122	43,306,000

[1] total number of employees including office, clerical, supervisory, mining and production
[2] estimated from Nova Scotia Departmet of Natural Resources sources
NOTE: Production represents shipments; numbers may not add to totals due to rounding

Table 1.6. Metallic mineral production for the calendar year 1999.

COMPANY	LOCATION	PRODUCTION		TOTAL NUMBER EMPLOYED	APPROX. VALUE($)[2]
		TROY OZ.	g		
GOLD					
Tangier Limited Partnership[1]	Tangier, Halifax County	63	1960	n/a	24,000
TOTAL FOR METALLIC MINERAL PRODUCTION				n/a	24,000

[1] operated for part of year only
[2] value based on average annual metal price
Note: Production represents shipment

PIONEER COAL LIMITED

Manager:	C. Chisholm
Address:	P. O. Box 929 Westville, N. S. B0K 2A0
Production:	252,262 tons (228 851 tonnes) of coal
Employees:	36

Pioneer Coal began mining coal from the Foord Seam at the Stellarton mine site, Pictou County, in March 1996. The Foord Seam is approximately 40 feet thick. Mechanical equipment is used to break the coal and overlying rock and the material is excavated using hydraulic excavators, conveyors and off-road haul trucks. Mining in the western end of the pit was completed during the year and mining is proceeding in the eastern side of the pit. The company conducted mining operations at the site from January through June and September through December.

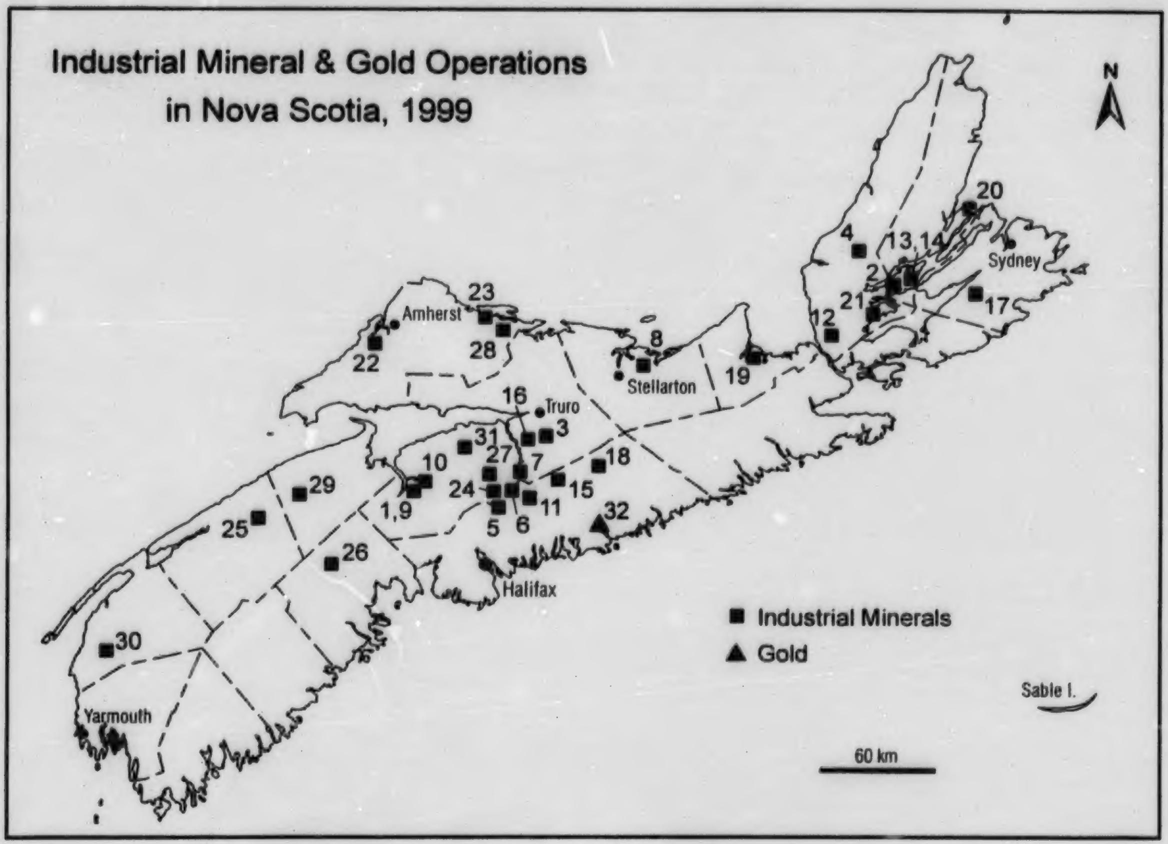
The coal mined from the Stellarton operation is blended on-site with coal trucked from the Evans Coal Mine, the Thorburn Mine and the Coalburn Mine before being shipped to Nova Scotia Power generating stations.

THORBURN MINING LIMITED

Manager:	C. Chisholm
Address:	P. O. Box 929 Westville, N. S. B0K 2A0

Thorburn Mine

Production:	19,981 tons (18 127 tonnes) of coal
Employees:	26


Industrial Mineral & Gold Operations in Nova Scotia, 1999
N
Amherst
Truro
Stellarton
Halifax
Sydney
Yarmouth
Sable I.
■ Industrial Minerals
▲ Gold
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32

Anhydrite
1. Fundy Gypsum Co.
2. Little Narrows Gypsum Co.

Barite
3. E-Z-EM Canada Inc.
4. Lynx Minerals Inc.

Clay and Shale
5-8. Shaw Brick, a member of the Shaw Group Limited

Gypsum
9-10. Fundy Gypsum Co.
11. National Gypsum (Canada) Ltd.
12. Georgia-Pacific Corp.
13-14. Little Narrows Gypsum Co.
15. Tusket Mining Incorporated

Limestone & Dolomite
16. Lafarge Canada Inc.
17. Nova Scotia Power Incorporated
18. Mosher Limestone Co. Ltd.
19. Ridge Brokers Ltd.
20. Scotia Limestone Ltd.
21. Shaw Resources, a member of the Shaw Group Limited

Salt
22. Sifto Canada Inc.
23. The Canadian Salt Company Limited

Silica Sand
24. Shaw Resources, a member of the Shaw Group Limited

Dimension Stone
25. Heritage Memorials Ltd.
26. Lange Natural Rock and Stone Supplies
27. Scotia Slate Products Ltd.
28. Wallace Quarries Ltd.

Peat Moss
29. Annapolis Valley Peat Moss Co.
30. Clare Organic Products Limited
31. MacDonald Peat Moss Limited

Gold
32. Tangier Limited Partnership

Figure 1.5. Location of industrial mineral and gold operations in Nova Scotia, 1999.

Mining at the Thorburn site, Pictou County, began in June 1995. In 1999, the mine operated during the January through April period.

Coal was extracted from the McBean Seam crown pillar and from pillars remaining from the former underground mining operations. The pit was expanded to the north during 1999. Overburden and waste rock were removed by ripping with bulldozers. Material was loaded and hauled using hydraulic excavators and dump trucks. The seam varies in thickness from 4 to 7 feet.

Coalburn Mine

Production: 17,282 tons (15 678 tonnes) of coal
Employees: 12

The Coalburn Surface Coal Mine is located in Coalburn, Pictou County. The mine began operations in June 1999, and coal was mined from July through September. The initial mining is being carried out in the Upper MacKay seam, a seam approximately 0.9 m in thickness. Overburden and waste rock were broken by ripping with bulldozers and the material was loaded and hauled using hydraulic excavators and dump trucks.

The overlying waste rock was difficult to break mechanically, and the operator suspended operation in September in order to amend the operating permits to allow blasting.

CAPE CRUSHING COMPANY LIMITED

Manager: E. Brogan
Address: P. O. Box 265
North Sydney, N. S. B2A 3M3
Production: 23,649 tons (21 454 tonnes) of coal
Employees: 2

The company operates a small surface coal mine at Alder Point, Cape Breton County, to supply the local domestic market. Coal was mined during the year from the Bonar Seam. Mining is carried out using mechanical equipment to break the coal and overlying rock.

BROGAN MINING COMPANY LIMITED

Manager: R. Brogan
Address: P. O. Box 190
Florence, N. S. B0C 1J0
Production: 39,819 tons (36 124 tonnes) of coal
Employees: 18

During the year, Brogan Mining Limited began full scale operation of its surface coal mine at Little Pond, Cape Breton County. Coal is recovered from the Lloyd Cove (Bonar) seam. The overlying waste rock and coal are broken mechanically and mining is carried out using bulldozers, a dragline, hydraulic excavators and dump trucks. The coal production is marketed to Nova Scotia Power Inc.

The company also carried out reclamation work at its mine sites at Toronto Road and Sullivan Creek, Cape Breton County, during 1999.

BERICHAN RESOURCES LIMITED

Manager: Michael P. Cullen
Address: 2071 Poplar Street
Halifax, N. S. B3L 2Y6
Production: 19,163 tons (17 385 tonnes) of coal
Employees: 18

Berichan Resources Limited operated its surface coal mine at Cottam Settlement, Colchester County, for four months during the year. Following pre-stripping operations, coal mining began in May. However, the operation was closed in September due to groundwater inflow problems and displacements in the coal seams. The company reclaimed almost all of the site in the fall of 1999.

Coal was recovered from three coal seams with thicknesses of 0.7 m to 1.5 m. The overlying waste rock and coal were broken mechanically and mining was carried out using bulldozers, hydraulic excavators and dump trucks. The coal production was marketed to Nova Scotia Power Inc.

HILL RECLAMATION LIMITED

Manager: M. McCormick
Address: R. R. #1
Springhill, N. S. B0M 1X0
Production: 14,794 tons (13 421 tonnes)
Employees: 19

Hill Reclamation resumed operation of the rail bed coal recovery project in 1999. The operation is located near Springhill, Cumberland County. The company recovers coal from an abandoned railway bed and markets the coal to Nova Scotia Power Inc. The site had previously been operated by Black Gold Enterprises Limited.

Industrial Minerals Mining

Gypsum and Anhydrite

FUNDY GYPSUM COMPANY

Manager: K. Hillman
Address: P. O. Box 400
Windsor, N. S. B0N 2T0
Production: 76,989 tons (69 844 tonnes) of anhydrite
1,857,632 tons (1 685 233 tonnes) of gypsum
Employees: 166

The Fundy Gypsum Company operates quarries and crushing plants in the Wentworth Road and Miller's Creek areas near Windsor, Hants County. In 1999, the company produced gypsum from its Bailey Quarry at Miller's Creek and both gypsum and anhydrite from three of the Wentworth quarries. The Wentworth ore is processed in the company's heavy media plant to separate the anhydrite and the gypsum.

The gypsum and anhydrite are transported by unit train to ship-loading facilities at Hantsport, a distance of 19 km. These products are shipped to wallboard and cement plants in the United States and Canada.

GEORGIA-PACIFIC CANADA INC.

Manager: R. L. Fraser
Address: P. O. Box 400
Port Hawkesbury, N. S. B0E 2V0
Production: 1,844,017 tons (1 672 881 tonnes) of gypsum
Employees: 124

Georgia-Pacific Corporation operates a gypsum quarry at Sugar Camp, Inverness County. Overburden at the site is removed using a dragline, trucks and shovels. The gypsum is drilled, blasted and transported to the crusher by trucks. Most of the quarry's production is transported by highway trucks to ship loading facilities at Point Tupper, Richmond County, a distance of 19 km. Georgia-Pacific also supplies gypsum to the wallboard plant at Point Tupper.

LITTLE NARROWS GYPSUM COMPANY

Manager: B. H. Allan
Address: R. R. #1
Little Narrows, N. S. B0E 1T0
Production: 103,044 tons (93 481 tonnes) of anhydrite
1,279,595 tons (1 160 841 tonnes) of gypsum
Employees: 101

Little Narrows Gypsum Company operates two gypsum quarries and an anhydrite quarry near Little Narrows, Victoria County. All the gypsum and anhydrite produced is shipped from the company's dock on the Bras d'Or Lakes to destinations in Canada and the United States.

NATIONAL GYPSUM (CANADA) LTD.

Manager: P. C. Mills
Address: P. O. Box 57
Milford, N. S. B0N 1Y0
Production: 3,753,638 tons (3 405 278 tonnes)
Employees: 100

National Gypsum (Canada) Ltd. operates the largest gypsum quarry in the province at East Milford, Halifax County. The gypsum is drilled, blasted and loaded onto trucks with loaders and hydraulic excavators. The gypsum is crushed, screened, and transported by unit train from Milford to Wright's Cove, Dartmouth, a distance of 45 km, where it is loaded onto ships for points in Canada and the United States.

TUSKET MINING INCORPORATED

Manager: C. E. Bain
Address: P. O. Box 48100
Bedford, N. S. B4A 3Z2
Production: 0 tons (0 tonnes)

Activity at the Murchyville Mine, Halifax County, was limited to the excavation of a 7 500 tonne sample in 1999. Approximately 4 200 tonnes of the sample material was shipped to a wallboard plant for assessment during the year.

Salt

THE CANADIAN SALT COMPANY LIMITED

Manager: A. W. Davidson
Address: P. O. Box 160
Pugwash, N. S. B0K 1L0
Production: 843,375 tons (765 105 tonnes) of salt
Employees: 210

The Canadian Salt Company Limited operates an underground salt mine at Pugwash, Cumberland County. The salt is mined by a room and pillar system of extraction, using diesel/electric drills, undercutters, loaders and trucks. The primary production during the year was from the 1000 level with secondary production from the 730 and 830 levels. The company completed a major program to install a steel shaft liner in the upper section of the No. 2 Shaft during the year.

The processing plant at the site produces a wide range of salt products, including industrial grades of salt, salt blocks for farm use, and fine salt for domestic consumption. Transportation is by road, rail or from the company owned ship-loading facility at Pugwash.

SIFTO CANADA INCORPORATED

Manager: D. E. Dickie
Address: P. O. Box 550
Amherst, N. S. B4H 4A1
Production: 84,616 tons (76 763 tonnes) of salt
Employees: 73

Salt has been produced from the solution salt mine at Nappan, Cumberland County, since 1947. Salt is mined by pumping water into underground wells where salt is dissolved and the resulting brine solution is then returned to the surface. The salt is recovered from the brine in a processing plant, using a 'mechanical vapour recompression evaporating process' system. The plant produces a wide range of refined salt products.

During the year, salt was produced from the No. 7 and No. 8 brine wells.

Barite

E-Z-EM CANADA INCORPORATED, NYSTONE DIVISION

Manager: V. J. Prostak
Address: P. O. Box 69
Debert, N. S. B0M 1G0
Production: 659 tons (598 tonnes) of pharmaceutical grade barite
Employees: 16

E-Z-EM Canada's barite deposit is located 1.6 km northeast of Brookfield, Colchester County. During 1999, approximately 1,686 tons of ore was produced from the surface mine. The ore was trucked to the company's plant at Debert where it was upgraded to a pharmaceutical quality product. The refined product is shipped to the parent company, E-Z-EM Corporation, New York, USA, for further processing and packaging.

LYNX MINERALS INC.

Manager: G. W. Felderhof
Address: Box 6, Site 9, R. R. #1
Trenton, N. S. B0K 1X0
Production: 4,840 tons (4 391 tonnes) of barite
Employees: 10

Lynx Minerals' barite deposit is located near Scotville, Inverness County. The company began development of the surface mining operation in June 1999. The barite product was shipped by truck to Upper Musquodoboit for grinding and is then used in drilling fluids for the offshore drilling industry. Site operations were closed down for the season in September 1999.

Limestone and Dolomite

LAFARGE CANADA INC.

Manager: J. Cross
Address: P. O. Box 5
Brookfield, N. S. B0N 1C0
Production: 543,434 tons (493 000 tonnes) of limestone
Employees: 11 (quarry) 79 (cement plant)

Lafarge Canada Inc. operates a limestone quarry near their Brookfield cement plant, 5 km west of Brookfield, Colchester County. The total production from the quarry is used at the plant.

MOSHER LIMESTONE COMPANY LIMITED

Manager: D. M. Mosher
Address: P. O. Box 28
Upper Musquodoboit, N. S.
B0N 2M0
Production: 48,555 tons (44 049 tonnes) of dolomite/limestone
Employees: 17

Mosher Limestone operates a number of quarries near Upper Musquodoboit, Halifax County. The company produces agricultural grade dolomite/limestone in its grinding plant at Upper Musquodoboit. The product is bagged or supplied in bulk for distribution throughout the Atlantic Provinces. The company also produces a pelletized limestone product for the domestic garden market.

SHAW RESOURCES, A MEMBER OF THE SHAW GROUP LIMITED

Manager: K. Hardie
Address: P. O. Box 60
Shubenacadie, N. S. B0N 2H0
Production: 0 tons (0 tonnes) of marble

Shaw Resources produces marble intermittently from a quarry at Marble Mountain, Inverness County. This marble is used for brick manufacture and in landscaping. There was no production reported in 1999.

RIDGE BROKERS LIMITED

Manager:	E. Alward
Address:	P. O. Box 175 Havelock, N. B. E0A 1W0
Production:	5,989 tons (5 433 tonnes) of limestone
Employees:	1

The company operates a small quarry at Southside Antigonish Harbour, Antigonish County, producing limestone for the agricultural market.

SCOTIA LIMESTONE LIMITED

Manager:	D. M. Mosher
Address:	P. O. Box 28 Upper Musquodoboit, N. S. B0N 2M0
Production:	4,669 tons (4 236 tonnes) of dolomite
Employees:	1

The Kelly's Cove dolomite quarry and plant are located near New Campbellton, Victoria County. The plant produces an agricultural grade dolomite for domestic sale, a ground dolomite product for coal mine stone dust, and dolomite products for the offshore steel industry. All 1999 production came from the existing ore inventory and no mining took place at the site during 1999.

NOVA SCOTIA POWER INCORPORATED (OPERATED BY KELLY ROCK LIMITED)

Manager:	D. W. MacKenna (Kelly Rock Limited)
Address:	P. O. Box 1206 Sydney, N. S. B1P 6J9
Production:	83,441 tons (75 700 tonnes) of limestone
Employees:	10

The limestone quarry at Glen Morrison, Cape Breton County, began production in 1993. The operation produces several products at the on-site crushing and screening facility. During 1999, most of the production from this site was shipped to Point Aconi for use in the fluidized bed power generating station. Kelly Rock Limited operates the quarry on behalf of Nova Scotia Power Incorporated.

Clay

SHAW BRICK, A MEMBER OF THE SHAW GROUP LIMITED

Manager:	B. Frizzell
Address:	P. O. Box 2130 Lantz, N. S. B0N 1R0
Production:	28,000 tons (25 401 tonnes) of clay & shale
Employees:	4

Shaw Brick mines clay from pits at Lantz and Milford, Hants County, and shale from quarries located in Hardwood Lands, Hants County, and New Glasgow, Pictou County. These materials are used in the company's plant in Lantz for the manufacture of bricks and other structural clay products.

Silica Sand

SHAW RESOURCES, A MEMPER OF THE SHAW GROUP LIMITED

Manager:	G. Dickie
Address:	P. O. Box 60 Shubenacadie, N. S. B0N 2H0
Production:	53,929 tons (48 424 tonnes) of silica sand
Employees:	6

Shaw Resources produces silica sand from a deposit at West Indian Road, Hants County. This sand is processed into several silica sand products including glass grade sand.

Dimension Stone

HERITAGE MEMORIALS LIMITED

Manager:	G. Nelson
Address:	P. O. Box 308 Windsor, N. S. B0N 2T0
Production:	1,685 tons (1 529 tonnes) of granite (est.)
Employees:	20

The company periodically operates a small quarry at Nictaux West, Annapolis County. The grey granite is used as dimension stone at the company's memorial manufacturing plant at Windsor, Hants County.

WALLACE QUARRIES LIMITED

Manager: S. Flynn
Address: P. O. Box 203
Wallace, N. S. B0K 1Y0
Production: 262 tons (238 tonnes) of building stone
Employees: 5

The Wallace Quarries, located near Wallace, Cumberland County, supply building stone for building rehabilitation work in Halifax and central Canada. Blocks of stone are sent for cutting to processing facilities in Nova Scotia, New Brunswick and Quebec to supply local markets.

Other

Two other stone operations, for which production information was not available at the time of publication, were Scotia Slate Products Ltd. and Lange Natural Rock and Stone Supplies. Scotia Slate operates a small slate quarry and fabrication facility near East Gore, Hants County, producing slate for local, domestic and international markets. Lange Natural Rock and Stone Supplies operates a small granite quarry near Parkdale, Lunenburg County, producing mainly European-style cobblestones.

Peat Moss

ANNAPOLIS VALLEY PEAT MOSS COMPANY LIMITED

President: H. Endres
Address: Berwick, N. S. B0P 1E0
Production: 6,021 tons (5 462 tonnes) of peat moss (estimated)
Employees: 24 (some part time)

The company uses vacuum harvesters to recover agricultural peat from a 500 acre (200 ha) bog located near Berwick, Kings County. Baled peat products are shipped to markets in Canada, the United States and Japan.

CLARE ORGANIC PRODUCTS LIMITED

Owner: Gerald Thimot
Address Box 174-A, Saulnierville
Digby County, N. S. B0W 2Z0
Production: 2,924 tons (2 653 tonnes) of peat moss (estimated)
Employees: 20 (some part time)

The company uses vacuum harvesters to recover agricultural peat from a 200 acre (81 ha) bog located near Meteghan Station, Digby County. The company has a contract to supply a major Maritime peat producer with baled peat destined for international markets.

MACDONALD PEAT MOSS LIMITED

Owner: Lameque Quality Group Ltd.
Address 86 Tourbe Street
Lameque, N. B. E8T 1A3
Production: 4,734 tons (4 295 tonnes) of peat moss (estimated)
Employees: 18

MacDonald Peat Moss Limited, a wholly-owned subsidiary of New Brunswick's Lameque Quality Group Ltd., has lease rights to a 1700 acre (688 ha) peat bog located on Crown land, approximately 12 km west of Kennetcook, Hants County. 1999 was the second year of production for the company, which exports baled peat to international markets.

Aggregate Resources

Approximately 11 million tonnes of construction aggregates were produced in Nova Scotia in 1999. Twenty-seven companies reported crushed stone production totalling 7.9 million tonnes while 44 producers reported sand and gravel production totalling 2.6 million tonnes. The majority of aggregate was consumed within the province, with approximately 2 million tonnes exported.

Two companies eclipsed the 1 million tonne mark for crushed stone production in 1999. Rocky Lake Quarry Limited of Bedford, Nova Scotia, reported shipments of 1.4 million tonnes while Martin Marietta Materials Canada Ltd. reported just over 2.2 million tonnes shipped. Martin Marietta's Porcupine Mountain operation was the country's seventh largest in 1999.

Appendix 2

Minerals and Energy Branch Geoscience Maps and Publications for Sale

BEDROCK GEOLOGY MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Map ME 2000-1 Geological Map of the Province of Nova Scotia, compiled by J. D. Keppie, 2000, scale 1:500 000. **$20.00**

Regional Scale

1:250 000

Map ME 1994-1 Geological Map of the South Mountain Batholith, Western Nova Scotia, compiled by M. A. MacDonald with contributions from M. C. Corey, L. J. Ham and R. J. Horne, 1994, scale 1:250 000. **$6..00**

1:125 000

Map ME 1983-4 Geological Map of the Red River Anorthosite Complex, Inverness and Victoria Counties, Nova Scotia, by P. K. Smith and A. S. Macdonald, scale 1:125 000. **$1.50**

Map ME 1978-1 Preliminary Geology Map of the Cobequid Highlands, by H. V. Donohoe and P. I. Wallace, scale 1:125 000, (Superseded by Map ME 1982-6, Map ME 1982-7, Map ME 1982-8, Map ME 1982-9, scale 1:50 000). **$3.50**

1:100 000

OFM ME 1998-1 Preliminary Geological Map of Guysborough, Richmond and Antigonish Counties (parts of NTS sheets 11E/08, 11F/05, 11F/06, 11F/10, 11F/11, 11F/12 and 11F/15, Nova Scotia, Canada, by C. E. White and S. M. Barr, 1998, 1 coloured map, scale 1:100 000. **$5.00**

Map ME 1984-2 Geological Map of the Boisdale Peninsula, Central Cape Breton Island, Cape Breton County, Nova Scotia, by Sandra M. Barr and Jeremy R. D. Setter, 1984, scale 1:100 000. **$4.00**

Map ME 1979-014 Pleistocene geology map of the Eastern Shore Region, Halifax and Guysborough Counties, Nova Scotia [sheet 3 of 3] [11D/14, 11D/15 and 11E/02 and parts of 11D/11 and 11E/03] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova Scotia Department of Mines and Energy Paper ME 1979-4.]

Map ME 1979-013 Pleistocene geology map of the Eastern Shore Region, Guysborough and Halifax Counties, Nova Scotia [sheet 2 of 3] [11E/01 and parts of 11E/02, 11E/07, 11E/08, 11E/11, 11F/04, 11F/05, 11C/13, 11D/15 and 11D/16] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova

Scotia Department of Mines and Energy Paper ME 1979-4.]

Map ME 1979-012 Pleistocene geology map of the Eastern Shore Region, Guysborough County, Nova Scotia [sheet 1 of 3] [11F/06 and parts of 11F/03, 11F/04, 11F/05, 11F/07, 11F/11 and 11F/12] [1:100 000], by R. R. Stea, J. H. Fowler, Nova Scotia Department of Mines and Energy, 1979, 1 map. [This map accompanies Nova Scotia Department of Mines and Energy Paper ME 1979-4.]

Detailed Scale

1:50 000

OFM ME 2000-3 Preliminary Geological Map of the Wolfville/Windsor Area, Hants and Kings Counties, Nova Scotia [21H/01 and Parts of 21A/16C and D], compiled by R. G. Moore, S. A. Ferguson, R. C. Boehner, C. M. Kennedy, 2000, 1 colour map, scale 1:50 000. **$5.00**

OFM ME 1999-3 Geological Map of the Musquodoboit Batholith, Halifax County [part of NTS sheet 11D/15], Nova Scotia, by L. J. Ham, 1999, 1 colour map, scale 1:50 000. **$5.00**

OFM ME 1999-2 Geological Map of the Musquodoboit Batholith, Halifax County [part of NTS sheet 11D/14], Nova Scotia, by L. J. Ham, 1999, 1 colour map, scale 1:50 000. **$5.00**

Map ME 1996-1 Geological Map of the Shubenacadie and Musquodoboit Basins Showing the Extent of Early Cretaceous Sediments (part of NTS Map Sheet 11E/03), Colchester and Halifax Counties, Nova Scotia, by R. R. Stea, P. W. Finck, S. E. Pullan, and M. C. Corey, 1996, scale 1:50 000. **$6.00**

Map ME 1994-8 Geological Map of Bridgetown, Nova Scotia (NTS Sheet 21A/14): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-7 Geological Map of Digby, Nova Scotia (NTS Sheet 21A/12): South Mountain Batholith Project, by L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-6 Geological Map of Milford, Nova Scotia (NTS Sheet 21A/11): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1994-5 Geological Map of Kejimkujik Lake, Nova Scotia (NTS Sheet 21A/06 and part of 21A/07): South Mountain Batholith Project, by R. J. Horne and M. C. Corey, 1994, scale 1:50 000. **$6.00**

Map ME 1994-4 Geological Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by M. A. MacDonald and L. J. Ham, 1994, scale 1:50 000. **$6.00**

Map ME 1994-3 Geological Map of Wentworth Lake (NTS Sheet 21A/04 and part of 20P/13): South Mountain Batholith Project, by L. J. Ham and M. A. MacDonald, 1994, scale 1:50 000. **$6.00**

Map ME 1994-2 Geological Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West Half): South Mountain Batholith Project, by M. C. Corey and R. J. Horne, 1994, scale 1:50 000. **$6.00**

Map ME 1993-1 Geological Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by R. J. Horne, 1992, scale 1:50 000. **$6.00**

Map ME 1992-1 Geological Map of Gaspereau Lake (NTS Sheet 21A/15 and part of 21H/02), Nova Scotia, by M. A. MacDonald and L. J. Ham, 1992, scale 1:50 000. **$6.00**

Map ME 1990-14 Cumberland Basin Geology Map, Tatamagouche and Malagash, Cumberland, Colchester and Pictou Counties, by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000. **$6.00**

Map ME 1990-13 Cumberland Basin Geology Map, Oxford and Pugwash, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-12 Cumberland Basin Geology Map, Amherst, Springhill and Parrsboro, Cumberland County, by R. J. Ryan, R. C. Boehner, A. Deal and J. H. Calder, 1990, scale 1:50 000. **$6.00**

Map ME 1990-11 Cumberland Basin Geology Map, Apple River and Cape Chignecto, Cumberland County, by R. J. Ryan, R. C. Boehner and A. Deal, 1990, scale 1:50 000. **$6.00**

Map ME 1990-10 Geological Map of Windsor (21A/16, West Half and part of 21H/01), Nova Scotia, by L. J. Ham, scale 1:50 000. **$6.00**

Map ME 1990-9 Geological Map of Chester (21A/09), Nova Scotia, by M. C. Corey, scale 1:50 000. **$7.00**

Map ME 1989-4 Geology of Mabou Highlands (NTS sheet 11K/03, west half), Nova Scotia, by S. M. Barr and A. S. Macdonald, 1989, colour map, scale 1:50 000 (accompanies Paper ME 1989-2). **$3.00**

Map ME 1987-8 Bedrock Geological Map of Mount Uniacke (11D/13 West), by M. C. Corey, 1987, scale 1:50 000. **$6.00**

Map ME 1987-7 Bedrock Geological Map of Windsor (21A/16 East), by L. J. Ham and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1987-6 Bedrock Geological Map of Halifax and Sambro (11D/12 and 11D/05), by M. A. MacDonald and R. J. Horne, 1987, scale 1:50 000. **$6.00**

Map ME 1986-1 Geological Map of the Sydney Basin, Cape Breton Island, Nova Scotia, by R. C. Boehner and P. S. Giles, 1986, scale 1:50 000. **$5.00**

Map ME 1985-2 Geological Map of the Loch Lomond Basin and Glengarry Half Graben, by R. C. Boehner and G. Prime, scale 1:50 000. **$5.00**

Map ME 1982-9 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Debert - Mt. Thom Region, Sheet 4 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-8 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Economy River - Folly Lake Region, Sheet 3 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-7 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Parrsboro - Five Islands Region, Sheet 2 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-6 Geological Map of the Cobequid Highlands, Colchester, Cumberland and Pictou Counties, Nova Scotia, Advocate Harbour - Port Granville Region, Sheet 1 of 4, by H. V. Donohoe, Jr., and P. I. Wallace, scale 1:50 000. **$8.00 each, $25.00 set of Map ME 1982-6 to Map ME 1982-9**

Map ME 1982-5 Geological Map of the Northern Antigonish Highlands, Nova Scotia, by J. B. Murphy, J. D. Keppie and A. Hynes, scale 1:50 000. **$4.00**

Map ME 1982-4 Geological Map of the Shubenacadie and Musquodoboit Basins, by P. S. Giles and R. C. Boehner, scale 1:50 000 **$5.00**

Map ME 1982-3 Geological Map of the Eureka Area, by P. S. Giles, scale 1:50 000. **$3.00**

Map ME 1982-2 Geological Map of the Antigonish Basin, by R. C. Boehner and P. S. Giles, scale 1:50 000. **$3.00**

1:31 680

Map ME 1967-3 Geology, Area of Christopher McLeod Brook, Victoria County, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1967-2 Geology, Middle River Area, Inverness and Victoria Counties, Nova Scotia, by G. C. Milligan, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1967-1 Geology, Crowdis Mountain Area, Victoria County, Nova Scotia, by G. C. Milligan, R. C. Parsons, B. White, R. M. Creed and A. K. Chatterjee, 1967, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1963-2 Geology, Boisdale Hills, Scotch Lake to Steeles Crossing, Cape Breton County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1963-1 Geological Map of the Craignish Hills, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1963, colour map, scale 1:31 680 (accompanies Memoir ME 7). **$3.00**

Map ME 1962-1 Geology, North Mountain, Inverness County, Nova Scotia, by G. C. Milligan and R. C. Parsons, 1962, black/white map, scale 1:31 680 (accompanies Memoir ME 7). **$1.00**

1:25 000

Map ME 1997-1 Geological Map of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, scale 1:25 000. Accompanies Paper ME 1997-1. **$6.00**

Map ME 1995-2, Second Edition Geological Map of a Portion of the South-Central Cape Breton Highlands (parts of NTS Map Sheets 11K/07 and 11K/10), Victoria and Inverness Counties, Nova Scotia, by R. J. Horne, revised September 1996, scale 1:25 000. $6.00

OFM ME 1994-6 Bedrock Geology Map of the Southeast Cape Breton Highlands, Nova Scotia (part of NTS Sheet 11K/07), Inverness and Victoria Counties, by L. J. Ham, 1994, scale 1:25 000. **$2.00**

OFM ME 1994-2 Location Map of Bedrock Samples, South-Central Cape Breton Highlands (NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne and L. J. Ham, 1994, scale 1:25 000 (2 sheets). **$4.00**

OFM ME 1994-1 Bedrock Geology Map of the South-Central Cape Breton Highlands, Nova Scotia (parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, by R. J. Horne, 1994, scale 1:25 000. **$2.00**

OFM ME 1991-1 Preliminary Geological Map of West-Central Cape Breton Highlands (11K/07 and 11K/10), by R. J. Horne, 1991, scale 1:25 000. **$2.00**

Map ME 1986-2 Geological Map of the Windsor Area, Nova Scotia, by Reginald G. Moore and Stewart A. Ferguson, 1986, scale 1:25 000. **$5.00**

Map ME 1983-1 Geological Map of the Hantsport Area, Nova Scotia, compilation and geology by S. A. Ferguson, scale 1:25 000. **$5.00**

1:20 000

OFM ME 1998-14 Geological Map of the McAdams Lake area, Cape Breton County (parts of NTS sheets 11F/15, 11F/16, 11K/01 and 11K/02) Nova Scotia, by C. E. White and S. M. Barr, 1998, 1 colour map, scale 1:20 000. **$5.00**

1:10 000

OFM ME 1998-13 Geological Map of Renfrew (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-12 Geological Map of Bill Meadow Mountain (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne and D. Fox, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-11 Geological Map of Woodville (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, Nova Scotia Department of Natural Resources, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-10 Geological Map of Newport Corner (part of NTS sheet 11D/13), Hants County, Nova Scotia, by R. J. Horne, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-9 Geological Map of Waverley (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-8 Geological Map of Middle Sackville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne, L. A. MacDonald and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-7 Geological Map of Lucasville (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and L. A. MacDonald, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-6 Geological Map of Fall River (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by R. J. Horne and D. E. Baker, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-5 Geological Map of Soldier Lake (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by M. Feetham, R. J. Horne, D. E. Baker and L. J. Ham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1998-4 Geological Map of Halifax Airport (part of NTS sheet 11D/13), Halifax County, Nova Scotia, by D. E. Baker, R. J. Horne and M. Feetham, 1998, 1 coloured map, scale 1:10 000. **$5.00**

OFM ME 1997-6 Geological Map of Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-5 Geological Map of Greenfield (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-4 Geological Map of Greenhill (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-3 Geological Map of East Gore (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-2 Geological Map of Upper Rawdon (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

OFM ME 1997-1 Geological Map of Upper Nile Mile River (part of NTS sheet 11E/04), Hants County, Nova Scotia, by R. J. Horne, 1997, scale 1:10 000. **$5.00**

Map ME 1995-1 Geological Map of the Springhill Coalfield, Cumberland County, Nova Scotia, by J. H. Calder, 1995, scale 1:10 000. **$6.00**

OFM ME 1994-5 Preliminary Geological Map, Rawdon Area, Hants County, Nova Scotia (NTS Sheet 11E/04), by R. J. Horne, 1994, scale 1:10 000. **$2.00**

OFM ME 1993-2 Geological Map of the Cogmagun River - Goshen Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1993-1 Geological Map of the Cheverie - Lower Burlington Quadrangle (NTS 21H/01), Nova Scotia, by R. G. Moore, 1993, scale 1:10 000. **$2.00**

OFM ME 1992-6 Geological Map of the Debert - Kemptown Coalfield (parts of NTS 11E/05, 06, 07, 11, 12), by R. Naylor, 1992, scale 1:10 000 (6 sheets). **$12.00 set**

OFM ME 1989-1 Geological Map of the Kentville-South Alton Quadrangle, compiled by Stewart A. Ferguson, 1989, scale 1:10 000. **$2.00**

OFM ME 1989-3 Geological Map of the Newport Corner Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1989-2 Geological Map of the West Gore Quadrangle, by R. G. Moore, 1988, scale 1:10 000. **$2.00**

OFM ME 1988-43 Preliminary Geological Maps of the Cumberland Basin, Amherst (21H/16), by R. C. Boehner, R. J. Ryan and A. Deal, 11 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-42 Preliminary Geological Maps of the Cumberland Basin, Springhill and Apple River (21H/09 and 21H/10), by R. J. Ryan, A. Deal, J. H. Calder and R. C. Boehner, 24 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-41 Preliminary Geological Maps of the Cumberland Basin, Cape Chignecto and Parrsboro (21H/07 and 21H/08), by A. Deal, R. J. Ryan and R. C. Boehner, 13 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-40 Preliminary Geological Maps of the Cumberland Basin, Pugwash and Malagash (11E/13 and 11E/14), by R. J. Ryan, R. C. Boehner and A. Deal, 21 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-39 Preliminary Geological Maps of the Cumberland Basin, Tatamagouche and Oxford (11E/11 and 11E/12), by R. J. Ryan, R. C. Boehner and A. Deal, 23 maps, scale 1:10 000. **$2.00 each**

OFM ME 1988-24 Geological Map of New Minas - Canaan Quadrangle, compiled by Dr. Stewart A. Ferguson 1988, scale 1:10 000. **$2.00**

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:5000

OFM ME 1989-17 Geological Map of the Stellarton Basin (West Half), Pictou County, Nova Scotia, by W. D. Smith, K. S. Gillis, S. A. Montgomery, scale 1:5000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:240

Map ME 1968-1 Silver Cliff Prospect, Dauphinee Brook, Inverness County, Nova Scotia, by G. C. Milligan and A. K. Chatterjee, 1968, black/white map, scale 1:240 (accompanies Memoir ME 7). **$1.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill

Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

GLACIAL/SURFICIAL GEOLOGY MAPS

Provincial Scale

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:500 000

Map ME 1992-3 Surficial Geology Map of the Province of Nova Scotia, compiled by R. R. Stea, H. Conley and Y. Brown, 1992, scale 1:500 000. **$5.00**

Regional Scale

1:250 000

Map ME 1992-2 Glacial Geology Map of the South Mountain Batholith (NTS Sheets 11D, 21A and 20P), Western Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:250 000. **$5.00**

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each, $10.00 set**

1:100 000

Map ME 1990-6 Surficial Geology Map of Parts of Halifax, Pictou, Antigonish and Guysborough Counties (Sheet 12), Map Sheets 11E/09, 10, 15, 16 and parts of 11E/07 and 11E/08, by R. R. Stea and R. A. Myers, 1990, scale 1:100 000. **$13.00**

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1988-14 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 11), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1988-13 Surficial Geology Map of Parts of Colchester, Cumberland, Pictou and Hants Counties, Nova Scotia (Sheet 10), by R. R. Stea and P. W. Finck, 1988, scale 1:100 000. **$4.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

OFM ME 1998-3 Surficial Geology of the Shubenacadie area (NTS 11E/03), Colchester, Halifax and Hants Counties, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

OFM ME 1998-2 Surficial Geology of the Bridgetown area (NTS 21A/14), Annapolis County, Nova Scotia, by R. R. Stea and C. M. Kennedy, 1998, 1 coloured map, scale 1:50 000. **$5.00**

Map ME 1994-14 Glacial and Till Clast Geology Map of Gaspereau Lake, Nova Scotia (NTS Sheet 21A/15): South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. B. Bent, 1994, scale 1:50 000. **$6.00**

Map ME 1994-13 Glacial and Till Clast Geology Map of Milford, Nova Scotia (NTS 21A/11): South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-12 Glacial and Till Clast Geology Map of Kejimkujik Lake, Nova Scotia (NTS Sheets 21A/06 plus part of 21A/07): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-11 Glacial and Till Clast Geology Map of Weymouth, Nova Scotia (NTS Sheet 21A/05): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

Map ME 1994-10 Glacial and Till Clast Geology Map of Wentworth Lake, Nova Scotia (NTS Sheet 21A/04 plus part of 20P/13): South Mountain Batholith Project, by P. W. Finck, F. J. Boner and R. M. Graves, 1994, scale 1:50 000. **$6.00**

Map ME 1994-9 Glacial and Till Clast Geology Map of Lake Rossignol, Nova Scotia (NTS Sheet 21A/03 West): South Mountain Batholith Project, by P. W. Finck, R. M. Graves and F. J. Boner, 1994, scale 1:50 000. **$6.00**

OFM ME 1993-13 Glacial and Till Clast Geology Map of Digby (NTS 21A/12), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1993, scale 1:50 000. **$2.00**

Map ME 1993-2 Glacial and Till Clast Geology Map of New Germany (NTS Sheet 21A/10), Nova Scotia, by P. W. Finck, R. M. Graves and F. J. Boner, 1992, scale 1:50 000. **$6.00**

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. **$2.00 per NTS Map Sheet**

Map ME 1990-4 Till Clast and Glacial Geology Map of Chester (21A/09), Nova Scotia, by R. M. Graves and P. W. Finck, 1990, scale 1:50 000. **$11.00**

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

OFM ME 1988-14 Glacial and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by P. W. Finck, R. M. Graves, F. J. Boner and H. G. Bent, scale 1:50 000. **$2.00**

Map ME 1987-4 Till Clast and Simplified Glacial Geology Map of Halifax-Sambro (11D/12 and 11D/05), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-3 Till Clast and Simplified Glacial Geology Map of Mount Uniacke (11D/13 West), by R. M. Graves and P. W. Finck, 1987, scale 1:50 000. **$6.00**

Map ME 1987-2 Glacial Geology Map of Halifax and Sambro (11D/12 and 11D/05), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

Map ME 1987-1 Glacial Geology Map of Mount Uniacke (11D/13 West), by P. W. Finck and R. M. Graves, 1987, scale 1:50 000. **$6.00**

1:25 000

OFM ME 1992-2 Surficial Geology of the South-Central Cape Breton Highlands (11K/07), by P. W. Finck, 1992, scale 1:25 000. **$2.00**

GEOCHEMISTRY MAPS

Provincial Scale

1:1 500 000

OFM ME 1990-15 Geochemical Atlas of Nova Scotia: Part I, Drainage Surveys, compiled by P. A. Lombard, 119 maps, 4 overlays. **$50.00**

Regional Scale

1:100 000

OFM ME 1988-51 Till Geochemistry Map of Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:100 000. **$2.00**

OFM ME 1988-50 Till Geochemistry Map of Northern Mainland Nova Scotia, Clay Fraction Analyses, Antigonish and Guysborough Counties, by R. G. Turner and R. R. Stea, Map Sheet 13-88, scale 1:00 000. **$2.00**

OFM ME 1988-32 Till Geochemistry Map, Northern Mainland Nova Scotia, Heavy Mineral Separate Analyses (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

OFM ME 1988-31 Till Geochemistry Map, Pictou and Antigonish Counties (Sheet 12), by R. G. Turner and R. R. Stea, scale 1:100 000. **$2.00**

Map ME 1982-10 Pleistocene Geology and Till Geochemistry Map of Southwestern Nova Scotia (Sheets 7 and 8), by R. R. Stea and D. R. Grant, scale 1:100 000, (Sheet 9 is Map 1630A in Geological Survey of Canada Paper 85-17). **$8.00**

Map ME 1982-1 Pleistocene Geology and Till Geochemistry Map of South-Central Nova Scotia (Sheet 6), by R. R. Stea, scale 1:100 000, (Sheet 5 is in Open File Report ME 555). **$3.50**

Map ME 1981-1 Pleistocene Geology and Till Geochemistry Map, Central Nova Scotia, (Sheet 4; Sheets 1, 2 and 3 are in Paper ME 1979-4), by R. R. Stea and J. H. Fowler, scale 1:100 000. **$3.50**

Detailed Scale

1:50 000

OFM ME 1988-52 Preliminary Till Geochemistry and Till Clast Geology of the Windsor Map Sheet (21A/16), South Mountain Batholith Project, by F. J. Boner, P. W. Finck and R. M. Graves, scale 1:50 000. **$2.00**

GEOPHYSICS MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

1:500 000

Map ME 1979-3 Geological Map of Nova Scotia, Bouguer Gravity Anomaly Edition, by J. D. Keppie, scale 1:500 000, 1979, with Metamorphic and Structural Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

Regional Scale

1:125 000

Map ME 2000-2 Enhanced Aeromagnetic and Digital Elevation Map of Eastern Nova Scotia, compiled by M. S. King, 2000, scale 1:250 000. **$6.00**

Map ME 1983-2 Calculated Vertical Magnetic Gradient Map of the Cape Breton Highlands, Inverness and Victoria Counties, Nova Scotia, scale 1:125 000. **$5.00**

Detailed Scale

1:50 000

OFM ME 1997-33 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/15, Port Mouton, Queens and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-32 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/14, Shelburne, Shelburne and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-31 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20P/13, Tusket, Yarmouth and Shelburne Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-30 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 20O/16, Yarmouth, Yarmouth County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-28 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/09, Chester, Lunenburg and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-27 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/08, Lunenburg, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-26 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/07, Bridgewater, Lunenburg and Queens Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-25 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/04, Wentworth Lake, Yarmouth and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-24 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/03, Lake Rossignol, Shelburne, Yarmouth, Queens and Digby Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-23 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/02, Liverpool, Queens and Lunenburg Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-22 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 21A/01, LaHave Islands, Lunenburg County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. $5.00
OFM ME 1997-21 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/12, Halifax, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-20 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/05, Guysborough, Guysborough and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-19 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/04, Country Harbour, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-18 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11F/03 and 11F/06, Larrys River and Chedabucto Bay, Guysborough County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-17 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/08, Lochaber, Pictou, Guysborough, and Antigonish Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-16 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/04, Kennetcook, Hants County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-15 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/03, Shubenacadie, Halifax, Colchester and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-14 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/02, Upper Musquodoboit, Halifax, Guysborough and Colchester Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-13 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11E/01, Liscomb, Guysborough and Halifax Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-12 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/16, Ecum Secum, Halifax and Guysborough Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-11 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/15, Tangier, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-10 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/14, Musquodoboit Harbour, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-9 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/13, Mount Uniacke, Halifax and Hants Counties, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-8 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/11, West Chezzetcook, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

OFM ME 1997-7 Meguma Terrane Enhanced (Second Vertical Derivative) Aeromagnetic Digital Data, NTS Map Sheet 11D/10, Owls Head, Halifax County, Nova Scotia, by M. S. King, 1997, scale 1:50 000. **$5.00**

MINERAL DEPOSITS MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. **$1.00** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1998-15 Map of Active Mines in Nova Scotia, by Ian McLellan, June 1998, 1 map, scale 1:1 000 000. **$5.00**

1:500 000

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Map ME 1991-1 Map of Gypsum and Anhydrite Resources in Nova Scotia, compiled by G. C. Adams, 1991, scale 1:500 000 (accompanies EGS ME 1991-1). **$5.00**

Map ME 1985-1 Industrial Mineral Commodities Map of the Province of Nova Scotia, compiled by John H. Fowler, 1985, scale 1:500 000. **$5.00**

Map ME 1983-5 Metallogenic Map of Nova Scotia, by A. K. Chatterjee, scale 1:500 000, 1983. **$5.00**

Map ME 1983-3 Salt and Potash Resources Map of Nova Scotia, by R. C. Boehner, scale 1:500 000 (accompanies Bulletin ME 5). **$2.00 (white print copies only)**

Map ME 1979-2 Geological Map of Nova Scotia, Metallic Mineral Occurrence Edition, by J. D. Keppie, D. J. Gregory, A. K. Chatterjee and N. A. Lyttle, scale 1:500 000, 1979, with Structural and Metamorphic Map Inserts by J. D. Keppie and G. K. Muecke, scale 1:1 000 000. **$2.50** (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

Regional Scale

1:250 000

Map ME 1989-3 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 3 (Cape Breton Island), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-2 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 2 (Central Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

Map ME 1989-1 Map of the Peatland Areas of Nova Scotia, by A. R. Anderson and W. A. Broughm, Sheet 1 (Southwestern Nova Scotia), 1986, scale 1:250 000 (accompanies Bulletin ME 6). **$2.00 (white print copies only)**

1:125 000

Map ME 1985-6 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000 (locates and shows the type, quality and observed thickness of sand and gravel deposits). **$3.00**

Map ME 1985-3, Map ME 1985-4, Map ME 1985-5 Aggregate Resources Map, Cape Breton Island, by W. J. Wright, scale 1:125 000, (locates and names aggregate pits and quarries). **$3.00 each, $10.00 set**

1:100 000

OFM ME 1986-49 to OFM ME 1986-56 Gold Compilation of the Meguma Terrane in Nova Scotia, by J. McMullin, G. Richardson, T. Goodwin, 8 maps, scale 1:100 000. **$2.00 each**

Detailed Scale

1:50 000

OFM ME 1991-5 to OFM ME 1991-18 Aggregate Potential of Cumberland and Colchester Counties, 14 Preliminary Map Sheets, scale 1:50 000 (11E/02, 11E/03, 11E/05, 11E/06, 11E/07, 11E/11, 11E/12, 11E/13, 11E/14, 21H/07, 21H/08, 21H/09, 21H/10, 21H/16), by G. Prime, 1991. **$2.00 per NTS Map Sheet**

1:6000

OFM ME 1990-2 Map of the Glencoe Limestone Deposit, Inverness County (11F/14), 1988 Diamond-Drilling; Diamond-Drill Holes and Sections, by R. H. MacDonald, scale 1:6000. **$2.00**

1:1600

Map ME 1990-3 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 830 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-2 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 730 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

Map ME 1990-1 Geological Map of the Canadian Salt Company Limited Pugwash Mine (11E/13A), 630 Level, Pugwash, Nova Scotia, by D. C. Carter, 1990, scale 1:1600. **$5.00**

1:70

Map ME 1984-1 Geological Map of the Cochrane Hill Open-Pit Gold Deposit, Guysborough County, Nova Scotia, by P. K. Smith, scale 1:70. **$8.00**

STRUCTURE/TECTONIC MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. $1.00 (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:500 000

Map ME 1982-11 Tectonic Map of Nova Scotia, by J. D. Keppie, scale 1:500 000, 1982. **$5.00**

LAND-USE MAPS

Provincial Scale

1:500 000

OFM ME 2000-1 Land Designation and Ownership in Nova Scotia, researched and compiled by David Hopper, Fred J. Bonner and Brian E. Fisher, 2000, scale 1:500 000. **$5.00**

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Detailed Scale

1:50 000

OFM ME 1989-5 to OFM ME 1989-9 Mineral Resource Land Use Maps for Lunenburg County, by D. B. Hopper and H. J. Gillis, 1989, 5 maps, scale 1:50 000. **$2.00 per map, $10.00 set**

OFM ME 1988-44 to OFM ME 1988-49 Mineral Resource Land Use Maps for Kings County (21A/10, 21A/15, 21A/16, 21H/01, 21H/01, 21H/02, 21H/08), by D. B. Hopper and H. J. Gillis, 1989, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-33 to OFM ME 1988-38 Mineral Resource Land Use Maps for Cape Breton County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-17 to OFM ME 1988-22 Mineral Resource Land Use Maps for Hants County, by D. B. Hopper and H. J. Gillis, 1988, 6 maps, scale 1:50 000. **$2.00 per map; $12.00 set**

OFM ME 1988-1 to OFM ME 1988-12 Mineral Resource Land Use Maps for Halifax County, by D. B. Hopper and C. A. Dobson, 1988, 12 maps, scale 1:50 000. **$2.00 per map; $24.00 set**

GENERAL MAPS

Provincial Scale

1:2 000 000

Map ME 1979-5 to Map ME 1979-9 Folio of Geological Maps of Nova Scotia - includes Geological, Structural, Metamorphic, Classes of Mineral Deposits, Bouguer Gravity Anomaly and Magnetic Maps, by J. D. Keppie, G. K. Muecke, A. K. Chatterjee and others, scale 1:2 000 000, 1979. $1.00 (Please note that Geological Map ME 2000-1 is the most recent provincial scale geology map of Nova Scotia)

1:1 000 000

OFM ME 1999-1 Index map to Nova Scotia Department of Natural Resources Bedrock Geology, Surficial Geology and Aeromagnetic Open File Maps of Nova Scotia [scale 1:1 000 000], compiled by K. D. Fraser, 1999, 1 map. **$5.00**

OFM ME 1998-16 Index Map to Geological Survey of Canada Open File Geological Maps of Nova Scotia, 1969-1998, by K. D. Fraser, T. L. Lenfesty, 1998, scale 1:1 000 000. **$2.00**

OFM ME 1998-15 Map of Active Mines of Nova Scotia, by Ian McLellan, June, 1998, 1 map, scale 1:1 000 000. **$5.00**

1:640 000

Outside Publication ME 1989-1 Geological Highway Map of Nova Scotia, Second Edition, by Howard V. Donohoe, Jr., and R. G. Grantham, scale 1:640 000, 1989 (Atlantic Geoscience Society, Special Publication Number 1). **$3.50**

1:500 000

Claim Reference Map (compilation) of Nova Scotia, updated quarterly, scale 1:500 000. **$5.00**

OFM ME 1997-35 Historic Underground Mining + Advanced Exploration Sites: Abandoned Mine Openings, compiled by Mining Engineering Section, Nova Scotia Department of Natural Resources, September 24, 1997. **$5.00**

Detailed Scale

1:31 680

Claim Reference Maps of Nova Scotia, undated, scale 1:31 680. **$1.00 per 1:50 000 NTS Map Sheet Quarter Section**

ACTS

Provincial legislation.

Mineral Resources Act and Regulations, S.N.S. 1990, c. 18. **$9.35**

Gypsum Mining Income Tax Act, R.S.N.S. 1979, c. 190. **$1.00**

Treasure Trove Act, 1954. **FREE**

ANNUAL REPORTS

Summary reports of the Department's activities and programs.

1993/94

Annual Report for the Fiscal Year Ending March 31, 1994, by Nova Scotia Department of Natural Resources, 1995, 89 pages. **FREE**

1992/93

Annual Report for the Fiscal Year Ending March 31, 1993, by Nova Scotia Department of Natural Resources, 1994, 83 pages. **FREE**

1991/92

Annual Report for the Fiscal Year Ending March 31, 1992, by Nova Scotia Department of Natural Resources, 1994, 77 pages. **FREE**

1990/91

Annual Report for the Fiscal Year Ending March 31, 1991, by Nova Scotia Department of Mines and Energy, 1992, 117 pages. **FREE**

BULLETINS

Detailed scientific reports on various geoscience topics on a regional or provincial basis.

Bulletin ME 7 Structure of the Canadian Appalachians, by J. D. Keppie, 1992, 89 pages, 3 maps, 3 figures in back pocket. **$8.00 (Microfiche $2.00)**

Bulletin ME 6 Evaluation of Nova Scotia's Peatland Resources, by A. R. Anderson and W. A. Broughm, 1988, 109 pages, 3 maps, scale 1:250 000. **$15.00**

Bulletin ME 5 Salt and Potash Resources in Nova Scotia, by R. C. Boehner, 1986, 346 pages, 8½" x 11" format, includes Map ME 1983-3, scale 1:500 000. **$17.00 (Microfiche $5.00)**

Bulletin ME 4 Barite, Celestite and Fluorite in Nova Scotia, by G. W. Felderhof, 1978, 463 pages, 200 figures, 12 tables. **$13.00**

Bulletin ME 3 Assessment of Peat Moss Occurrences in Guysborough, Antigonish, Pictou, Colchester and Cumberland Counties, Nova Scotia, by D. R. Sutherland and F. S. Shea, 1976, 301 pages. **$7.00**

Bulletin ME 2 (Part 1) Limestones and Dolomites of Nova Scotia, Part I - Cape Breton Island, by F. S. Shea and D. A. Murray, 1969, 300 pages, 1 map. **$4.00**

Bulletin ME 2 (Part 2) Limestones and Dolomites of Nova Scotia, Part II - Antigonish, Guysborough, Pictou, and Cumberland Counties, by D. A. Murray, 1975, 155 pages. **$6.50**

Note: For Part 3, Colchester and Halifax Counties, see Open File Report ME 2000-3.

Bulletin ME 1 Port Hawkesbury Project - Geology, Geochemistry and Groundwater Investigations of Southwest Inverness and Richmond Counties, Nova Scotia, by F. S. Shea and J. D. Wallace, 1962, 73 pages, 5 maps. **$2.00**

ECONOMIC GEOLOGY SERIES

Detailed scientific reports on mineral commodities of economic or potential economic interest.

EGS ME 1996-1 Building Stone in Nova Scotia, by G. B. Dickie, 1996, 165 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-2 Aggregate Potential of Cumberland and Colchester Counties, Nova Scotia, by G. Prime, 1992, 172 pages. **$10.00 (Microfiche $3.00)**

EGS ME 1992-1 Various Industrial Mineral Commodities in Nova Scotia, by R. H. MacDonald, 1992, 99 pages. **$7.00 (Microfiche $2.00)**

EGS ME 1991-1 Gypsum and Anhydrite Resources in Nova Scotia, by G. C. Adams, 1991, 305 pages, 1 map, scale 1:500 000. **$25.00 (Microfiche $4.00)**

EGS ME 1990-3 Oil Shale Resources of Nova Scotia, by W. D. Smith and R. D. Naylor, 1990, 73 pages. **$12.00 (Microfiche $2.00)**

EGS ME 1990-2 Filler and Extender Minerals in Nova Scotia, by Peter Luke, 1990, 64 pages. **$6.00 (Microfiche $2.00)**

EGS ME 1990-1 Diatomaceous Earth Occurrences in Nova Scotia, by A. R. Anderson, 1990, 132 pages. **$15.00 (Microfiche $3.00)**

EGS ME 1989-1 Properties and Uses of Nova Scotia Clays and Shales, by Susan Gouthro, 1989, 288 pages. **$20.00 (Microfiche $3.00)**

EGS ME 1975-1 Iron Deposits of Nova Scotia, by J. D. Wright, 1975, 154 pages, 1 map. **$6.00**

EGS ME 1974-1 Geology and Trace Element Studies of Manganese Occurrences in Nova Scotia, by D. G. Bishop and J. D. Wright, 1974, 255 pages. **$7.50**

ILLUSTRATIONS

Geoscience diagrams other than maps.

Illustration ME 1998-3 Sydney Mines: Fossil Interpretation Project, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

Illustration ME 1998-2 Brule Fossil Site Project: Preserving and Developing a World Class Fossil Discovery in Nova Scotia, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

Illustration ME 1998-1 The Fossil Cliffs of Joggins: Towards World Heritage Site Designation, by J. H. Calder, 1998, 16" x 21" colour poster. **$12.00**

INFORMATION CIRCULARS

Free promotional pamphlets or booklets on various geoscience topics.

IC ME 60 Properties Available for Option in Nova Scotia, January 2000, by Nova Scotia Department of Natural Resources, 2000, 55 pages. **FREE**

IC ME 58 A Guide to Mineral Exploration Legislation in Nova Scotia, 1998, 8 pages. **FREE**

IC ME 55 Safe Work Methods Handbook, by Minerals and Energy Branch, Nova Scotia Department of Natural Resources, August 1997, 40 pages. **FREE**

IC ME 53 Secondary Processing of Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1998, 28 pages. **FREE**

IC ME 50 Carbonate-Hosted Zn-Pb-Ba-Ag-Cu Deposits in the Lower Carboniferous of Nova Scotia: The Irish Connection, by D. J. Kontak, 1996. **FREE**

IC ME 49 Ni-Cu-Co Associated with Mafic and Ultramafic Rocks of Cape Breton Island, by G. J. DeMont, 1996. **FREE**

IC ME 48 Cretaceous Kaolin Clay and Silica Sand Deposits in Nova Scotia, by P. W. Finck and R. R. Stea, 1996. **FREE**

IC ME 47 Vein and Breccia Deposits of Fe-Cu-Co-Ni-Ba-Au Associated with the Cobequid-Chedabucto Fault Zone, Nova Scotia, by G. A. O'Reilly, 1996. **FREE**

IC ME 46 Copper Deposits in the Carboniferous Rocks of Northern Nova Scotia, by R. J. Ryan, 1996. **FREE**

IC ME 45 Take Advantage of Mineral Exploration and Development in Nova Scotia, by Nova Scotia Department of Natural Resources, 1996. **FREE**

IC ME 42 A Sign to Watch Your Step, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995. (This information brochure describes hazards associated with abandoned mine sites). **FREE**

IC ME 41 Career Choices in the Petroleum Industry, by Petroleum Resources Section, Nova Scotia Department of Natural Resources, September 1993, 7 pages. **FREE**

IC ME 39 Petroleum Resources Offshore and Onshore Nova Scotia, Canada, by Nova Scotia Department of Natural Resources, Petroleum Resources Section, 1994, 7 pages. **FREE**

IC ME 36 Metalliferous Environments of Nova Scotia: Base Metals, by James M. Patterson, 1993, 18 pages. (This brochure summarizes Information Series ME 22.) **FREE**

IC ME 34 GEOFACTS: Industrial Minerals in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 33 GEOFACTS: Salt in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 32 GEOFACTS: Gypsum in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 31 GEOFACTS: Anhydrite in Nova Scotia, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, revised 1996, 4 pages. **FREE**

IC ME 30 GEOFACTS Modelling the Development of Rifted Continental Margins - "Time Travel by Computer", by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 29 GEOFACTS: Canada's Dynamic Coastline, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 27 GEOFACTS: Using Digital Sound in Marine Geoscience, by Energy, Mines and Resources Canada and Nova Scotia Department of Natural Resources, 1992, 4 pages. **FREE**

IC ME 25 One of the Greatest Treasures: The Geology and History of Coal in Nova Scotia, by J. H. Calder, K. S. Gillis, D. J. MacNeil, R. D. Naylor and N. Watkins-Campbell, 1993, 42 pages. **FREE**

IC ME 24 Industrial Minerals in Nova Scotia, by Nova Scotia Department of Natural Resources, Mineral Development Division, 1992, 25 pages. **FREE**

IC ME 22 Land Use Policy Development Project, by David B. Hopper and Andrew J. Kendall, November 1988. **FREE**

IC ME 21 A Walking Tour of Rocks, Minerals, and Building Stones of Prince Street, Truro, by Jo-Anne Goodwin et al., August 1988. **FREE**

IC ME 18 Peat Moss in Nova Scotia, by A. R. Anderson, 2nd edition, 1993. **FREE**

IC ME 11 A Walking Tour of Rocks, Minerals, and Landforms of Victoria Park, Truro, by Howard Donohoe and Martha Devanney, 1987. **FREE**

IC ME 10 A Walking Tour of Rocks, Minerals and Building Stones along Spring Garden Road, Halifax, by Katherine Bishop, Anne Stevenson, Martha Devanney and Howard Donohoe, 1987. **FREE**

IC ME 9 A Walking Tour of Rocks, Minerals and Landforms of Peggy's Cove, by Anita Sampson and Howard Donohoe, 1987. **FREE**

IC ME 7 A Walking Tour of Rocks, Minerals and Landforms of Point Pleasant Park, by Nova Scotia Department of Mines and Energy, June 1986. **FREE**

IC ME 4 Nova Scotia Gold, by Nova Scotia Department of Mines and Energy, May 1986. **FREE**

IC ME 3 A Walking Tour of Rocks, Minerals, and Building Stones in Downtown Halifax, by Nova Scotia Department of Mines and Energy, April 1986. **FREE**

IC ME 2 Mineral Rights, Landowners, and Mineral Exploration, by Nova Scotia Department of Mines and Energy, February 1986. **FREE**

IC ME 1 Directory of Goods and Services for Exploration Companies, by Shyanne LeBlanc, Trecia Schell, and Howard V. Donohoe, Jr., revised February 1993. **FREE**

INFORMATION SERIES

Promotional booklets on various geoscience topics.

IS ME 24 Twentieth Annual Review of Activities, by Nova Scotia Department of Natural Resources, Minerals and Energy Branch, 1996, 27 pages. **FREE**

Note: The Twenty-First Annual Review of Activities continues as Mining Matters in the Report Series.

IS ME 23 Abandoned Mine Openings: Hazards and Remediation Handbook, by Mining Engineering Section, Nova Scotia Department of Natural Resources, July 1995, 90 pages. (This handbook is intended to provide private landowners with information regarding the potential hazards and legal liabilities of abandoned mine openings located on their property, and to describe remedial methods to reduce or eliminate the hazard). **FREE**

IS ME 22 Metalliferous Environments in Nova Scotia, by James M. Patterson, 1993, 59 pages. **FREE**

IS ME 14 Reflection Seismic Coverage of Onshore and Nearshore Nova Scotia 1942-1987, compiled by P. G. McMahon, 1988, 34 pages, 3 maps in back pocket. **$5.00**

IS ME 13 Gold in Nova Scotia, by Jennifer Bates, 1987, 48 pages. **FREE**

IS ME 11 Surface Petroleum Shows, Onshore Nova Scotia, compiled by Gayle Short, March 1986, 33 pages. Out of Print **(Microfiche $1.00)**

IS ME 10 Petroleum Wells and Drillholes with Petroleum Significance, Onshore Nova Scotia, compiled by P. McMahon, G. Short, and D. Walker, January 1986, 194 pages. Out of Print **(Microfiche $2.00)**

MEMOIRS

Comprehensive, detailed scientific reports on the geology of specific areas.

Memoir ME 10 Geology of the Cumberland Basin, Cumberland, Colchester and Pictou Counties, Nova Scotia, by R. J. Ryan and R. C. Boehner, 1994, 222 pages, 155 text figures and back pocket containing 5 pocket figures, and 4 coloured geology maps: Map ME 1990-11, Map ME 1990-12, Map ME 1990-13 and Map ME 1990-14. **$69.00 (Microfiche $6.00)**

Memoir ME 9 Geology of the Loch Lomond Basin and Glengarry Half Graben, Richmond and Cape Breton Counties, Cape Breton Island, Nova Scotia, by R. C. Boehner and G. Prime, 1993, 68 pages, 1 map. (Includes Map ME 1985-2, Geology of the Loch Lomond Basin and Glengarry Half Graben, Nova Scotia, scale 1:50 000). **$8.00 (Microfiche $2.00)**

Memoir ME 8 Geology of the Antigonish Basin, Antigonish County, Nova Scotia, by R. C. Boehner and P. S. Giles, 1993, 132 pages. **$10.00 (Microfiche $3.00)**

Memoir ME 7 The Geology of the George River Series, Cape Breton, Stratigraphy, Structure and Economic Geology, by G. C. Milligan, 1970, 111 photocopied pages, 5 coloured and 2 black/white maps in back pocket: Map ME 1962-1, Map ME 1963-1, Map ME 1963-2, Map ME 1967-1, Map ME 1967-2 and Map ME 1967-3. **$10.00. (Microfiche $3.00)**

Memoir ME 5 Pleistocene Geology of the Annapolis Valley, Nova Scotia, by C. F. Hickox, 1962, 36 pages, 1 map. **$2.00**

Memoir ME 4 The Older Paleozoic of Pictou County, Nova Scotia, by R. H. Maehl, 1961, 109 pages, 1 appendix, 1 map. **$3.00**

Memoir ME 3 The Stratigraphy of the Windsor Group in the Antigonish Quadrangles and the Mahone Bay - St. Margaret's Bay Area, Nova Scotia, by Nathaniel McLean Sage, Jr., 1954, 168 pages. Out of Print **(Microfiche only $2.00)**

Memoir ME 2 Stratigraphy and Paleontology of the Windsor Group (Upper Mississippian) in parts of Cape Breton Island, Nova Scotia, by Maurice C. Stacy, 1953, 143 pages. Out of Print **(Microfiche only $3.00)**

Memoir ME 1 Gypsum and Anhydrite in Nova Scotia, by N. R. Goodman, 1952, 75 pages. Out of Print **(Microfiche only $2.00)**

MISCELLANEOUS PUBLICATIONS

Older reports on various geoscience topics that were originally published without a series title.

MP ME 1975-4 Bibliography of the Geology of Nova Scotia, by D. J. Gregory, 1975, 237 pages. Out of Print **(Microfiche only $4.00)**

MP ME 1975-3 Core Drilling in Nova Scotia with Government Drills, 1967-1971, 49 pages. **$1.00**

MP ME 1975-2 Drilling Logs of Government Core Drills, 1973, by I. MacDougall and D. W. Grimm, 76 pages. **$1.00**

MP ME 1975-1 Drilling Logs of Government Core Drills, 1972, by I. MacDougall and D. W. Grimm, 85 pages. **$1.00**

NOTE: Drilling logs after 1973 are published as part of the Report Series; e.g. Drilling Logs for 1974 are in Report ME 1976-1.

MP ME 1972-4 Geology of the Middle River and Baddeck Forks Map Areas, Victoria County, Nova Scotia, by B. E. Jones and T. G. N. Covert, 1972, 124 pages, 5 maps. **$5.00**

MP ME 1972-3 Clay and Sand Deposit at Elmsvale, Halifax County, Nova Scotia, by J. H. Fowler, 1972, 62 pages, drillhole sections. Out of Print **(Microfiche Only $2.00)**

MP ME 1972-1 Drilling Logs of Government Core Drills, 1971, by C. F. Townsend and D. W. Grimm, 81 pages. **$1.00**

MP ME 1971-1 Drilling Logs of Government Core Drills, 1970, by C. F. Townsend and D. W. Grimm, 71 pages. **$1.00**

MP ME 1970-1 Drilling Logs of Government Core Drills, 1969, by C. F. Townsend and D. W. Grimm, 65 pages. **$1.00**

MP ME 1969-2 Handbook for Companies Planning Offshore Drilling, by Nova Scotia Department of Mines, 1969, 23 pages. **$0.50**

MP ME 1969-1 Drilling Logs of Government Core Drills, 1968 by C. F. Townsend and D. W. Grimm, 58 pages. **$1.00**

MP ME 1968-2 Core Drilling in Nova Scotia with Government Drills, 1871-1966, 176 pages. **$2.00**

MP ME 1968-1 Drilling Logs of Government Core Drills, 1967, by C. F. Townsend and D. W. Grimm, 39 pages. **$1.00**

MP ME 1967-1 Drilling Logs of Government Core Drills, 1966, by C. F. Townsend and D. W. Grimm, 27 pages. **$1.00**

MP ME 1966-3 Metallic Mineral Occurrences Recorded in the Province of Nova Scotia, by Nova Scotia Department of Mines, 1966, 350 pages. **$4.00**

MP ME 1966-1 Drilling Logs of Government Core Drills, 1965, by C. F. Townsend and D. W. Grimm, 55 pages. **$1.00**

MP ME 1965-1 Drilling Logs of Government Core Drills, 1964, by C. F. Townsend and D. W. Grimm, 43 pages. **$1.00**

MP ME 1964-1 Drilling Logs of Government Core Drills, 1963, by C. F. Townsend and D. W. Grimm, 36 pages. **$1.00**

MP ME 1963-1 Drilling Logs of Government Core Drills, 1962, by C. F. Townsend and D. M. MacLeod, 35 pages. **$1.00**

MP ME 1962-1 Drilling Logs of Government Core Drills, 1961, by C. F. Townsend and D. M. MacLeod, 49 pages. **$1.00**

MP ME 1961-1 Drilling Logs of Government Core Drills, 1960, by C. F. Townsend and D. M. MacLeod, 33 pages. **$1.00**

MP ME 1960-1 Drilling Logs of Government Core Drills, 1959, by M. G. Goudge and D. M. MacLeod, 38 pages. **$1.00**

MP ME 1959-1 Drilling Logs of Government Core Drills, 1958, by M. G. Goudge and D. M. MacLeod, 34 pages. **$1.00**

MP ME 1958-2 Possibilities for Occurrence of Petroleum Reservoirs in Nova Scotia, by W. A. Bell, 1958, 177 pages. **$1.00**

NOTE: Drilling Logs prior to 1958 are in Nova Scotia Department of Mines Annual Reports.

NEWSLETTERS

A quarterly newsletter entitled "Nova Scotia Minerals Update" highlighting topical Minerals and Energy Branch and mineral industry news, events, activities and personnel.

Minerals Update, Volume 16, No. 4, Fall 1999. **FREE**

OPEN FILE ILLUSTRATIONS

Unpublished geoscience diagrams other than maps.

OFI ME 1998-2 What's New, Exploration and Development Highlights, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

OFI ME 1998-1 Industrial Minerals, Natural Gas Production in 1998 - New Opportunities, compiled by P. W. Finck, W. E. O'Halloran and G. A. Prime, 11" x 17" colour poster. **$2.00**

OFI ME 1990-4 Detailed Drillhole Correlation, Tatamagouche Area (11E/14), Cumberland Basin, by R. J. Ryan, 1990, scale 1:1538. **$2.00**

OFI ME 1990-3 Detailed Drillhole Correlation, Oxford Area (11E/12), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1177. **$2.00**

OFI ME 1990-2 Stratigraphic Section of the French River - River John Area (11E/11, 11E/14), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:1333. **$2.00**

OFI ME 1990-1 Stratigraphic Section of the Joggins Area (21H/09), Cumberland Basin, by R. J. Ryan and R. C. Boehner, 1990, scale 1:2400. **$2.00**

OPEN FILE REPORTS

Unpublished reports on various geoscience topics.

OFR ME 2000-3 Limestones and Dolomites of Nova Scotia, Part 3, Colchester and Halifax Counties, Nova Scotia, by D. A. Murray, 2000, 181 pages, 28 maps. [For Part 1, Cape Breton Island, see Bulletin ME 2, Part 1; for Part 2, Antigonish, Guysborough, Pictou and Cumberland Counties, see Bulletin ME 2, Part 2.] **$15.00**

OFR ME 2000-1 NTS Location, Author and Citation Index to Nova Scotia Department of Natural Resources, Minerals and Energy Branch Assessment Reports, 1996-1999, compiled by Paul D. McCulloch, Sandra Marshall, Norman A. Lyttle and J. Susan Saunders, 2000, 116 pages. **$10.00**

OFR ME 1998-5 Classic Carboniferous Sections of the Minas and Cumberland Basins in Nova Scotia: with Special Reference to Organic Deposits, by J. H. Calder, R. C. Boehner, D. E. Brown, M. R. Gibling, P. K. Mukhopadhyay, R. J. Ryan and D. M. Skilliter; The Society for Organic Petrology, Annual Meeting Field Trip Guide Book, 29-30 July, 1998, 86 pages. **$10.00**

OFR ME 1998-4 Petroleum Occurrence in Drillholes from the Pictou Coalfield, by K. S. Gillis, 1998, 17 pages, 1 fold out coloured map. **$7.00**

OFR ME 1998-1 Minerals and Energy Branch, Nova Scotia Department of Natural Resources, Province of Nova Scotia: An Organization Review, by C. G. Miller, Industry Government Relations Group, 1998, 60 pages. **$5.00**

OFR ME 1997-8 First Annual Nova Scotia Department of Natural Resources/Geological Survey of Canada (Atlantic) Joint Work Plan for Geoscience in Nova Scotia, 1997-1998, by H. Scott Swinden, Nova Scotia Department of Natural Resources, and J. Verhoef, Geological Survey of Canada (Atlantic), 15 pages. (Also available as Geological Survey of Canada Open File 3527). **$2.00**

OFR ME 1997-7 Report on the Diamond Drilling and Geological Investigations of the Steves Road Lead-Gold Occurrence, North Beaverbank, Hants County, Nova Scotia, by R. J. Ryan, 1997, 67 pages, 2 enclosures. **$10.00**

OFR ME 1997-6 Report on a Diamond-Drilling Program, Mile 16 East Road and MacKenzie Road South, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 33 pages, 1 coloured figure. **$5.00**

OFR ME 1997-5 Report on a Diamond-Drilling Program in the North Brook Area, Victoria County, Nova Scotia, by G. J. DeMont, 1997, 17 pages. **$3.00**

OFR ME 1997-4 Core Logs of Drillholes MER-95-1 and MER-95-2, Piedmont and Merigomish Island, Pictou County, Nova Scotia, by K. S. Gillis, 1997, 17 p. **$3.00**

OFR ME 1997-3 Physical and Chemical Analyses of Kaolin from the Musquodoboit Valley, Nova Scotia, Canada, by Minerex Laboratories, Inc., and Industrial Minerals Services, Inc., 1997, 53 p. **$10.00**

OFR ME 1997-1 Late Quaternary Glaciation and Sea-Level Change Along the Atlantic Coast of Nova Scotia, by R. R. Stea, 1997, 219 pages, 31 maps, 2 maps in pocket, (scale 1:80 000 and Map ME 1992-3 scale 1:500 000). This open file report is a reformatted copy of a thesis submitted in partial fulfilment of the requirements for the degree of Doctor of Philosophy at Dalhousie University, 1995. **$30.00**

OFR ME 1996-11 Evaluation of 17 Kaolin Samples from the Musquodoboit and Shubenacadie Valleys, Nova Scotia, by S. E. Valji, Minerex Laboratories, Inc., Milledgeville, Georgia, for Nova Scotia Department of Natural Resources, 1996, 13 pages, 11 black and white figures. **$5.00**

OFR ME 1996-9 Mineral Potential Assessment Procedures Using GIS and Expert Modelling Approach, by J. Wang, 1996, 51 pages, 6 coloured. **$25.00**

OFR ME 1996-8 Investigation of Epithermal-Type, Breccia-Hosted Pb-Zn-Ba-Au Mineralization Within the Tobeatic Shear Zone of Southwestern Nova Scotia, by M. C. Corey and R. M. Graves, 1996, 81 pages, 11 coloured, 2 coloured figures in pocket. **$25.00**

OFR ME 1996-6 Diamond-Drill Core Log of Nova Scotia Department of Natural Resources Drillhole WBK 93-1, Whitten Brook, Walton Woods Road, Hants County, Nova Scotia, by R. C. Boehner, 1996, 9 pages. **$3.00**

OFR ME 1996-5 Geology of the Foord Seam and Associated Strata in the Area of the Stellarton Pit Mine, Pictou Coalfield, Stellarton Basin, Nova Scotia, by K. S. Gillis, R. D. Naylor and J. W. F. Waldron, 1996, 23 pages, 1 geology Map, scale 1:5000, 3 figures (one coloured). **$15.00**

OFR ME 1996-3 Cretaceous-Aged Kaolin Clays and Silica Sands in the Shubenacadie and Musquodoboit Valleys, Nova Scotia, Canada, by R. R. Stea, P. W. Finck, S. Pullan and M. C. Corey, 1996, 25 pages, 8 maps. **$17.00**

OFR ME 1996-2 Geology of the Cambridge Cove/ Bramber and Red Head Map Areas 21H/01-Z1, Z3 and 21H/01-Y2, by Dr. R. G. Moore, 1996, 30 pages, 2 geology maps, scale 1:10 000, in back pocket. **$10.00**

OFR ME 1996-1 Zeolite Mineral Assemblages in the North Mountain Basalt, Nova Scotia, by G. Pe-Piper and D. Horton, 1996, 30 pages, 1 colour location map, scale 1:175 000, in back pocket. **$8.00**

OFR ME 1995-6 New Discoveries of Silica Sand and Kaolinite near Brierly Brook, Antigonish County, Nova Scotia, by R. R. Stea, P. W. Finck, G. Prime and G. J. DeMont; 1995, 5 pages. **$2.00**

OFR ME 1995-5 Reprocessing of Nova Scotia Gravity Data from the NSRF Gravity Database (1952-1988), for Mineral Resources Division, Nova Scotia Department of Natural Resources, by K. Howells and E. D. Clarke; 1995, 211 pages, 1 map and 4 discs of gravity data. **$45.00**

OFR ME 1995-3 A Compilation of Geological, Surficial, Geochemical and Geophysical Data along the Tobeatic Shear Zone in the Little Tobeatic Lake and Peter Lake Areas of Southwestern Nova Scotia, by R. M. Graves, 1995, 42 pages, with 14 figures (9 coloured) and 2 maps (1:25 000). **$15.00**

OFR ME 1995-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01 and 11K/02, Nova Scotia, by G. J. DeMont, 1995, 175 pages. $15.00
OFR ME 1995-1 Diamond-Drilling of Rare Element Pegmatites in Southwestern Nova Scotia, by M. C. Corey, 1995, 33 pages, with 10 figures. **$5.00**
OFR ME 1994-26 Preliminary Results of Drilling Quaternary and Cretaceous Sediments near Shubenacadie, Hants County, Nova Scotia, by P. W. Finck, R. R. Stea and D. F. Dwyer, 1994, 35 pages. **$4.00**

OFR ME 1994-23 Gold Mineralization in the Cape Breton Highlands, Nova Scotia, by P. K. Smith and G. A. O'Reilly, 1994, 16 pages. **$3.00**

OFR ME 1994-22 Geology of the Walton-Rainy Cove Brook Map-Area (NTS 21H/01-Z2 and Z4), Hants County, Nova Scotia, by R. G. Moore, 1994, 36 pages, 1 geological map, scale 1:10 000. **$6.00**

OFR ME 1994-21 Compilation of Seabright Resources Inc. Till and Soil Geochemical Data, Nova Scotia, by K. K. Woodman, R. R. Duncan, R. M. Graves, A. B. Hudgins and P. J. Rogers, 1994, 239 pages, 21 sample location maps, scale 1:50 000. **$50.00**

OFR ME 1994-20 Report on U-Pb Geochronology of Avalonian Rocks in Nova Scotia, by Donald W. Davis, 1994, 13 pages. **$3.00**

OFR ME 1994-16 Doughboy Point Drilling Program, Doughboy Point, Guysborough County, Nova Scotia, by R. H. MacDonald, 1994, 39 pages. **$4.00**

OFR ME 1994-15 Magnetic Signature of the Goldenville-Halifax Transition Zone: North Beaverbank, by M. S. King, 1994, 9 pages. **$3.00**

OFR ME 1994-13 Diamond-Drilling of the East Lake Tungsten Occurrence, Halifax County, Nova Scotia (NTS Sheet 11D/15), by M. C. Corey, 1994, 30 pages. **$5.00**

OFR ME 1994-12 Maximizing Investment by Timely Application of Desktop Digital Technology to Mineral Exploration: An Example from Nova Scotia, Canada, by P. J. Rogers, W. P. Jones and L. M. MacKenzie, 1994, 3 pages, includes 1 coloured figure. **$3.00**

OFR ME 1994-11 Recent Gold Discoveries on Cape Breton Island, Nova Scotia, by G. J. DeMont, 1994, 3 pages. **$1.00**

OFR ME 1994-10 Keyword Index to Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 14 pages of microfiche. **$3.00 (Microfiche only)**

OFR ME 1994-9 Author Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 250 pages. **$20.00**

OFR ME 1994-8 NTS Location Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches, Assessment Reports, Contribution Series, Open Files and Publications for 1991-1993, by Janette M. Vavra and Norman A. Lyttle, 1994, 175 pages. **$15.00**

OFR ME 1994-5 Report on Geological Mapping, Mineral Inventory Studies and Diamond-Drilling Surveys at the Rifle Range and Krumrine Quarries, Upper Leitches Creek, Cape Breton County, Nova Scotia, by G. J. DeMont, 1994, 35 pages, 1 map. **$5.00**

OFR ME 1994-4 Magnetic Mineralogy and Susceptibility of the North-Central Meguma Group: Implications for the Interpretation of Aeromagnetic Total Field, First Derivative and Second Derivative, by M. S. King, 1994, 41 pages, includes 7 coloured figures. **$5.00**

OFR ME 1994-3 Multi-Media Geochemical Survey of the Dominique (Sn, Zn, Cu) Deposit, (NTS 20O/16), Yarmouth County, Nova Scotia, by P. A. Lombard and F. J. Boner, 1994, 170 pages. **$15.00**

OFR ME 1993-32 The Economic Impact of the Mineral Industry in Nova Scotia, prepared for Energy, Mines and Resources Canada, by Gardner Pinfold Consulting Economists Limited, August 1993, 74 pages. **$7.00**

OFR ME 1993-29 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia on NTS Map Sheets 11F/09, 11F/10, 11F/15, 11F/16, 11K/01, by G. J. DeMont, 1993, 296 pages. **$15.00**

OFR ME 1992-20 Gold Potential in the Meguma Terrane: New Discoveries Combining Vertical Gradient Aeromagnetics, Biogeochemistry and Till Sampling, (NTS 21A/02 and 11E/08), by Paul K. Smith, Peter J. Rogers, Lyndon Jensen and Colin E. Dunn, 1992, 6 pages, 7 figures. **$2.00**

OFR ME 1992-16 Multi-Media Detailed Geochemical Study of the Brazil Lake Pegmatites (NTS 20P/13), Yarmouth County, Nova Scotia, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1992, 159 pages. **$15.00**

OFR ME 1992-14 Preliminary Report on Geological, Geochemical, Fluid Inclusion and Isotope Studies of the Gays River Pb/Zn Deposit, Nova Scotia (11E/03B), by Dan Kontak, 1992, 220 pages, includes coloured plates. **$25.00**

OFR ME 1992-10 Selected Metallic Mineral Occurrences of Cape Breton Island, Nova Scotia (NTS 11F/14, 11F/15, 11F/16, 11K/02, 11K/03, 11K/06, 11K/07, 11K/10, 11K/15, 11K/16), by Garth J. DeMont, 1992, 290 pages. **$20.00**

OFR ME 1992-9 Mineralogical Investigations along the Upper Seal Harbour Anticline, Goldboro, Nova Scotia (11F/04D), by M. C. Corey, 1992, 77 pages, includes coloured plates. **$20.00**

OFR ME 1992-8 Geological and Geochemical Observations within the Tangier Gold Deposit (11D/15C), by M. C. Corey and R. F. Mills, 1992, 138 pages. **$15.00**

OFR ME 1992-7 An Evaluation of Debris Avalanches in the Cape Breton Highlands, Nova Scotia, (11K/07 and part of 11K/10), by P. W. Finck, 1992, 68 pages. **$5.00**

OFR ME 1992-3 Multi-Media Detailed Geochemical Study of the Canfield Creek Cu-Ag Deposit, North-Central Nova Scotia, by M. A. MacDonald, 1992, 90 pages. **$9.00**

OFR ME 1991-18 Multi-Media Detailed Geochemical Study of the Yava Lead Deposit - East Zone, by M. A. MacDonald, F. J. Boner and P. A. Lombard, 1991, 162 pages. **$16.00**

OFR ME 1991-16 Selected Mineral Occurrences of the Cumberland and Stellarton Basins and their Metallogenetic Implications, by R. J. Ryan, 1991, 197 pages. **$15.00**

OFR ME 1991-11 Index Maps and Map Data Sheets to Nova Scotia Department of Mines and Energy and Geological Survey of Canada Published and Open File Geochemical Maps of Nova Scotia (compiled to August 1991), by P. L. LeBlanc, N. A. Lyttle, J. M. FREEman, 1991, 165 pages, 2 maps. **$6.00 Maps only; $22.00 complete**

OFR ME 1991-10 Index Map and Map Data Sheets to Published Geological Survey of Canada Coloured Total Field and Vertical Gradient Aeromagnetic Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. FREEman, 1991, 50 pages, 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-15). **$2.00 Map only; $7.00 complete**

OFR ME 1991-9 Index Map and Map Data Sheets to Published Nova Scotia Department of Mines and Energy and Geological Survey of Canada Surficial Geology Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 36 pages, 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-14). **$2.00 Map only; $5.50 complete**

OFR ME 1991-8 Index Map and Map Data Sheets to Published Nova Scotia Department of Mines and Energy Bedrock Geology Maps of Nova Scotia (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 64 pages, 1 map, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-11). **$2.00 Map only; $8.00 complete**

OFR ME 1991-7 Index Maps and Map Data Sheets to Published Geological Survey of Canada Bedrock Geology Maps of Nova Scotia (excluding Faribault - Fletcher Series), (compiled to August 1991), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1991, 129 pages, 2 maps, scale 1" to 16 miles (1:1 013 760). (This Open File Report supersedes Open File Report ME 1990-12). **$4.00 Maps only; $17.00 complete**

OFR ME 1991-3 Diamond-Drilling of the Big Indian Lake Polyphase Intrusive Suite, Halifax County, Nova Scotia (NTS Map 11D/13), by Michael C. Corey, 1991, 35 pages. **$4.00**

OFR ME 1991-2 Selected Metallic Mineral Occurrences of Cape Breton Island on NTS Map Sheets 11F/14, 11K/01, 11K/02, 11K/06, 11K/07, by Garth DeMont, 1991, 200 pages. **$15.00**

OFR ME 1990-24 A Study of Pits and Quarries Rehabilitation, prepared for Energy, Mines and Resources Canada, Mineral Policy Sector, by Gardner Pinfold Consulting Economists Limited in association with Robert Parker Associates Limited, Peter Klynstra Landscape Architects Limited, 1990, 146 pages. **$10.00**

OFR ME 1990-23 Selected Bibliography of the Geology (Including Economic Geology) of Carboniferous Basins in Nova Scotia, compiled by R. C. Boehner, 1990, 33 pages. **$3.00**

OFR ME 1990-22 Gypsum in the Murchyville Area (11D/14D), Halifax County, Nova Scotia, by G. C. Adams, 1990, 51 pages, 3 maps. **$10.00**

OFR ME 1990-20 1988 Glencoe Drilling Program, Inverness County, by R. H. MacDonald, 1990, 18 pages. **$4.00**

OFR ME 1990-19 Summary of the Major Limestone - Dolomite Deposits of Nova Scotia, by R. H. MacDonald, 1990, revised edition of Nova Scotia Department of Mines and Energy Open File Report ME 1986-64. **$3.00**

OFR ME 1990-17 Regional Geochemical Surveys Conducted by the Nova Scotia Department of Mines and Energy from 1957 to 1989, by P. J. Rogers and P. A. Lombard, 1991, 53 pages, 23 figures and 3 tables. **$10.00**

OFR ME 1990-16 Index Maps and Map Data Sheets to Published Geological Survey of Canada Redline Total Field and Vertical Gradient Aeromagnetic Maps of Nova Scotia (compiled to August 1990), by Patricia L. LeBlanc, Norman A. Lyttle, Janette M. Freeman, 1990, 97 pages, 2 maps, scale 1" to 16 miles (1:1 013 760). **$4.00 Maps only; $14.00 complete**

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OFR ME 1990-9 Investigation of the Chegoggin Point, Lake George, Yarmouth County (200/16), Silica and Garnet Deposit, by R. H. MacDonald, 1990, 74 pages. **$4.00**

OFR ME 1990-8 Quaternary Geology of Nova Scotia, compiled by R. R. Stea and R. J. Mott; Guidebook for 53rd Annual Friends of the Pleistocene Field Excursion, May 25-28, 1990, 85 pages, 61 figures. **$11.00**

OFR ME 1990-7 Lithogeochemistry of the Western Portion of the South Mountain Batholith, Nova Scotia (21A/03, 21A/04, 21A/05, 21A/06, 21A/11, 21A/12, 21A/14), by L. J. Ham, M. C. Corey, R. J. Horne and M. A. MacDonald, 1990, 30 pages, 3 maps, scale 1:150 000 and 1:250 000. **$7.00**

OFR ME 1990-6 Trace Element Analysis of Till (-230 Mesh), South Mountain Batholith, (11D/05, 11D/12, 11D/13, 20P/13, 21A/03, 21A/04, 21A/05, 21A/06, 21A/07, 21A/09, 21A/10, 21A/11, 21A/12, 21A/14, 21A/15, 21A/16, 21H/02), by F. J. Boner, P. W. Finck and R. M. Graves, 1990, 40 pages, 1 map, scale 1:250 000. **$6.00**

OFR ME 1990-5 Heavy Mineral Till Geochemistry (Tin) of the Western South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 40 pages, 3 maps. **$12.00**

OFR ME 1990-4 Heavy Mineral Till Geochemistry (Tin) of the Eastern and Central South Mountain Batholith, by P. W. Finck, F. J. Boner and R. M. Graves, 1990, 21 pages, 3 maps, scale 1:250 000. **$10.00**

OFR ME 1989-7 Geochemical Analyses of Bulk Stream Sediment Samples from Northern Nova Scotia, by R. F. Mills, 1989, includes many tables and 3 sample location maps, scale 1:250 000. **$40.00**

OFR ME 1989-6 Summary Report on Quarry Stone Used in the Construction of Dominion Building, Halifax, N. S., by G. B. Dickie, 1989, 16 pages. **$3.00**

OFR ME 1989-5 Open File Report on Selected Mineral Occurrences of the Cobequid Area, Nova Scotia, (NTS 11E/05, 11E/06, 11E/10, 11E/11, 11E/12, 21H/07, 21H/08), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 189 pages, many tables. **$15.00**

OFR ME 1989-4 Open File Report on Selected Mineral Occurrences of Southern Cape Breton Island, Nova Scotia, (NTS 11F/10, 11F/15, 11F/16, 11K/01, 11K/02), by K. E. Northcote, G. DeMont and A. Armitage, March 1989, 94 pages, tables. **$10.00**

OFR ME 1989-3 Open File Report on Selected Mineral Occurrences of the Antigonish Area, (NTS 11E/08, 11E/09 and 11E/16), by K. E. Northcote, G. DeMont and A. Armitage, February 1989, 184 pages, tables. **$15.00**

OFR ME 1989-1 Lithogeochemistry of the Eastern Portion of the South Mountain Batholith, Nova Scotia, (Map Sheets 11D/05, 11D/12, 11D/13, 21A/09, 21A/10, 21A/15, 21A/16, and parts of 21H/01 and 21H/02), by L. J. Ham, S. W. Marsh, M. C. Corey, R. J. Horne and M. A. MacDonald, 62 pages, 2 maps. **$15.00**

OFR ME 1988-63 An Assessment of the Hydrocarbon and Compressed Air Storage Potential of Nova Scotia: A Summary, by Nolan, Davis and Associates Ltd., 1988, 22 pages. **$3.00**

OFR ME 1988-59 Interpretation of Till Geochemical Data in Nova Scotia, Canada, Using Mapped Till Units, Multi-Element Anomaly Patterns, and the Relationship of Till Clast Geology to Matrix Geochemistry, by R. G. Turner and R. R. Stea, 1988, 39 pages. **$5.00**

OFR ME 1988-57 Gypsum - Anhydrite Potential, Meadows Road Area, Cape Breton County, by G. Adams, 1988, 29 pages. **$5.00**

OFR ME 1988-56 An Assessment of the Hydrocarbon and Compressed Air Storage Potential of Nova Scotia Salt Deposits, by Nolan, Davis and Associates Ltd., 1988, 195 pages. **$20.00**

OFR ME 1988-55 Multi-Element Ratings Maps for Meguma Zone Lake Sediments, by P. J. Rogers, 1989, 34 pages, 3 maps. **$5.00**

OFR ME 1988-40 Aggregate Market Study for New Brunswick and Nova Scotia, by ADI Limited, 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 309 pages. **$17.00**

OFR ME 1988-39 Marine Transport Study for Nova Scotia, by Leslie MacIntyre Maritime Associates Inc., May 1988, Prepared for Mineral Policy Sector, Energy, Mines and Resources Canada, 38 pages. **$5.00**

OFR ME 1988-13 A Study of U. S. East Coast Industrial Mineral Markets for New Brunswick, Newfoundland and Nova Scotia, by Metals Economics Group, 1988, Prepared for Mineral Policy Sector, Energy Mines and Resources Canada, 286 pages. **$15.00**

OFR ME 1988-11 Geochemical Investigations in the Rushmere - Moosefly Lakes Area, Yarmouth County, Nova Scotia (NTS 21A/04A), by R. F. Mills, 1988, 23 pages. **$3.00**

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OFR ME 1987-23 Report on the English Property (McKeen Quarry), Pictou County, by G. B. Dickie, 1987, 12 pages. **$5.00**

OFR ME 1987-5 Report on the Potential Stone Quarry, MacKenzie Farm, Hardwood Hill, Pictou County, Nova Scotia, by G. Dickie, 1986, 37 pages. **$5.00**

OFR ME 1987-2 Market Analysis for New Brunswick, Nova Scotia and Newfoundland Dimension Stone, by the DPA Group Incorporated in association with Jacques Whitford and Associates Limited, March 1987, 66 pages. **$10.00**

OFR ME 1986-54 The U.K. Experience on the Effects of Offshore Sand and Gravel Extraction on Coastal Erosion and the Fishing Industry, by R. Warren Drinnan and Douglas G. Bliss, Dobrocky Sea Tech Limited, August 1986, 90 pages. **$10.00**

OFR ME 1986-39 Agricultural Gypsum Project, by Peter Luke, 1986, 9 pages. **$3.00**

OFR ME 1986-25 The Gypsum Industry in Nova Scotia - Present Status and Future Prospects, by R. E. Wright and J. H. Brown; prepared for Nova Scotia Department of Mines and Energy by Centre for Resource Studies, Queen's University, 1985, 125 pages. **$15.00**

OFR ME 1986-21 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), 235 pages. **$10.00**

OFR ME 1986-20 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), 355 pages. **$10.00**

OFR ME 1986-19 Compilation of Drillhole Information from Open Assessment Reports Available to the End of December 1985: Central Nova Scotia (Map Sheets 11D, 11E), 280 pages. **$10.00**

OFR ME 1986-13 Study of Markets for Silica and Silica Sands Accessible from Nova Scotia and New Brunswick, by ADI Limited, 244 pages. **$10.00**

OFR ME 1986-12 A Study of Industrial Minerals Used in Oil and Gas Exploration on the Eastern Canadian Offshore, by Jacques, Whitford and Associates, and Cleland, Dunsmuir Consulting Limited, 231 pages. **$17.00**

OFR ME 1986-10 Study of Markets for Aggregate Materials Accessible from Nova Scotia and New Brunswick, by ADI Limited, March 1986, 398 pages. **$10.00**

NOTE: As of January 1986, all new Open File Reports have a report number assigned based upon the year of publication.

OFR ME 656 The Development Potential for Nova Scotia's Offshore Aggregate and Placer Resources, by John Fowler and Craig Miller, 1985, 69 pages. **$10.00**

OFR ME 651 Gypsum Property, Ownership and Leases, by Mark W. G. King, 1985, 140 pages. **$10.00**

OFR ME 650 Guide to the Granites and Mineral Deposits of Southwestern Nova Scotia, edited by A. K. Chatterjee and D. B. Clarke, 1985, 264 pages. **$15.00**

OFR ME 648 Current Market Economics of the Strontium Minerals by Metals Economic Group of Halifax, Nova Scotia, and Boulder, Colorado, 1985, 54 pages. **$5.00**

OFR ME 621 Effects of Location on Mine Development Potential: Nova Scotia's Competitive Position in Canada, by D. W. Davis, B. W. MacKenzie and M. L. Bilodeau, 1985, 103 pages. **$15.00**

OFR ME 608 Industrial Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 21 pages, 1 map. **$4.00**

OFR ME 607 Industrial Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11N), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 29 pages, 1 map. **$4.00**

OFR ME 606 Industrial Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D, 11E), by M. Ponsford, G. DeMont and N. A. Lyttle, 1985, 22 pages, 1 map. **$4.00**

OFR ME 605 Regional Lake Sediment Survey of the Meguma Zone, Southern Nova Scotia: New Analytical Data, by P. J. Rogers, M. A. MacDonald and D. W. Rigby, 1985, 65 pages, 2 maps. **$5.00**

OFR ME 603 Preliminary Feasibility Study for an Underground Gold Mining Operation in Central Nova Scotia, by Nova Scotia Department of Mines and Energy, 1984, 62 pages, 2 maps. **$5.00**

OFR ME 601 Metallic Mineral Occurrences Map and Data Compilation, Western Nova Scotia (Map Sheets 20O, 20P, 21A, 21B, 21H), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 600 Metallic Mineral Occurrences Map and Data Compilation, Eastern Nova Scotia (Map Sheets 11F, 11G, 11J, 11K, 11N), by M. Ponsford and N. A. Lyttle, 1984, 23 pages, 2 maps. **$3.00**

OFR ME 599 Metallic Mineral Occurrences Map and Data Compilation, Central Nova Scotia (Map Sheets 11D and 11E), by M. Ponsford and N. A. Lyttle, 1984, 21 pages, 2 maps. **$3.00**

OFR ME 329 The Glencoe Limestone and Dolomite Survey, by D. J. MacNeil, 1977, 252 pages, 12 maps. **$15.00**

OFR ME 50 Carboniferous Stratigraphy and Economic Geology, Halifax, Hants and Colchester Counties, Nova Scotia; Canadian Institute of Mining and Metallurgy, Geology Division, Field Guide, by Mining Society of Nova Scotia, Atlantic Geoscience Society and Nova Scotia Department of Mines, 1974, 48 pages. **$1.00**

OUTSIDE PUBLICATIONS

Various externally published reports and maps on geoscience topics authored by non-Minerals and Energy Branch staff.

OP ME 1998-2 A Special Issue Devoted to Lead-Zinc Mineralization and Basinal Brine Movement, Lower Windsor Group (Viséan), Nova Scotia, Canada; *in* Economic Geology and the Bulletin of the Society of Economic Geologists, v. 93, September-October 1998, no. 6, 260 pages. **$21.00**

OP ME 1998-1 Discovering Rocks, Minerals and Fossils in Atlantic Canada, A Geological Field Guide to Selected Sites in Newfoundland, Nova Scotia, Prince Edward Island, and New Brunswick, edited by P. Wallace, 1998, 186 pages; Atlantic Geoscience Society, Special Publication No. 14. **$25.00**

OP ME 1995-1 Proceedings: 30th Forum on the Geology of Industrial Minerals (1994), edited by S. A. A. Merlini, 1995; New Brunswick Department of Natural Resources and Energy, Minerals and Energy Division, Miscellaneous Report 16, 261 pages. **$14.75**

OP ME 1991-1 A Guide to the Geology, Landscapes and Mineral Resources of Nova Scotia, by Craig K. Miller and G. C. Milligan, 1991; Atlantic Geoscience Society, Special Publication No. 6 (Preliminary Edition), 188 pages. **$5.00**

OP ME 1988-1 Atlantic Geoscience Society, Colloquium '88, Antigonish, N. S. (Abstracts of Papers). **$4.00**

OP ME 1987-2 The Mining Society of Nova Scotia 1887-1987, by D. Pigot, published by the Mining Society of Nova Scotia, June 1987, 125 pages. **$10.00**

OP ME 1987-1 Quaternary Glaciations, Geomorphology and Sea Level Changes: Bay of Fundy Region, by R. R. Stea, Field Trip, July 19-30, 1987, for NATO Advanced Study Institutes Programme, International Advanced Course on Late Quaternary Sea Level Correlations and Applications, Halifax, Nova Scotia; 79 pages. **$10.00**

OP ME 1986-5 Trip No. 14 Lithostratigraphic, Physical Diagenetic and Economic Aspects of the Pennsylvanian-Permian Transition Sequence of Prince Edward Island and Nova Scotia; H. W. van de Poll, J. R. DeGrace, R. J. Ryan, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985). **$7.00**

OP ME 1986-4 Trip No. 11 Turbidite-Hosted Gold Deposits, Meguma Domain, Eastern Nova Scotia; P. K. Smith, S. J. Haynes, B. E. Jones, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 67 pages. **$7.00**

OP ME 1986-3 Trip No. 10 Igneous and Metamorphic Geology of the Cape Breton Highlands; S. M. Barr, R. A. Jamieson, R. D. Raeside, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 48 pages. **$5.00**

OP ME 1986-2 Behind the Headlines: Moose River to Shangri-La, by Ralph Kelly Morton, 1986; in Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 197 pages. **$14.95**

OP ME 1986-1 Trip No. 1 Appalachian Geotraverse (Canadian Mainland); J. D. Keppie, K. Currie, J. B. Murphy, *et al.*, 1986; *in* Geological Association of Canada/Mineralogical Association of Canada Guidebooks for Field Excursions (Fredericton, May 15-17, 1985), 181 pages. **$15.00**

OP ME 1981-1 Malagash Salt, compiled and edited by John R. MacQuarrie, c. 1975, 1981, 109 pages. **$5.00**

PAPERS

Detailed scientific papers on specific geoscience topics and/or specific areas.

Paper ME 1997-1 The Geology of a Portion of the South-Central Cape Breton Highlands (part of NTS map sheet 11K/07), Victoria and Inverness Counties, Nova Scotia, by L. J. Ham, 1997, 43 pages, 1 coloured map, includes Map ME 1997-1, scale 1:25 000 in back pocket. **$15.00**

Paper ME 1995-2 Geology of the South-Central Cape Breton Highlands (Parts of NTS Sheets 11K/07 and 11K/10), Inverness and Victoria Counties, Nova Scotia, by R. J. Horne, 61 pages, includes Map ME 1995-2 in back pocket. **$20.00**

Paper ME 1995-1 The Compositional Development of Tills Overlying the South Mountain Batholith, Nova Scotia, by P. W. Finck and R. R. Stea, 1995, 52 pages, includes Map ME 1992-2. **$15.00**

Paper ME 1994-1 A Diamond-Drilling Program near the Amherst Market, Investigating Bedrock Aggregate Potential in the Northwestern Cobequid Highlands, Nova Scotia, by G. Prime, 1994, 38 pages. **$4.00**

Paper ME 1993-2 Quaternary Stratigraphy and Placer Gold Potential of the Inner Scotian Shelf, by R. R. Stea, S. Pecore and G. B. J. Fader, 1993, 62 pages. **$7.00 (Microfiche $2.00)**

Paper ME 1993-1 An Evaluation of Debris Avalanches in the Central Cape Breton Highlands, Nova Scotia, by P. W. Finck, 1993, 65 pages. **$9.00 (Microfiche $2.00)**

Paper ME 1992-1 Surficial and Environmental Geology of the Western Cape Breton Highlands, Nova Scotia, by P. W. Finck, 1992, 22 pages, map and 18 plates in back pocket. **$10.00 (Microfiche $2.00)**

Paper ME 1989-3 Re-evaluation of the Coal Resources of Western Cape Breton Island, by P. A. Hacquebard, K. S. Gillis and D. S. Bromley, 1989, 47 pages. **$12.00 (Microfiche $2.00)**

Paper ME 1989-2 Geology of the Mabou Highlands, by S. M. Barr and A. S. Macdonald, 1989, 65 pages, 1 geological map in pocket. **$15.00 (Microfiche $3.00)**

Paper ME 1989-1 Metallogenic Studies of South-eastern Cape Breton Island, by A. S. Macdonald, 1989, 99 pages, 3 figures in pocket. **$20.00 (Microfiche $3.00)**

Paper ME 1986-1 Cretaceous Deposits of Nova Scotia, by G. B. Dickie, 1987, 54 pages. **$15.00 (Microfiche $3.00)**

Paper ME 1985-2 The Formation of Veins in Greenschist Facies Rocks and the Early Deformation of the Meguma Group, Eastern Nova Scotia, by B. H. O'Brien, 1985, 35 pages. **$3.00 (Microfiche $1.00)**

Paper ME 1984-1 Petrology of Granitoid Rocks of the Boisdale Peninsula, Central Cape Breton Island, Nova Scotia, by S. M. Barr and J. R. D. Setter, 1986, 75 pages, includes Map ME 1984-2 folded in back pocket. **$8.00 (Microfiche $2.00)**

Paper ME 1982-2 Metasomatic-Hydrothermal Mineral Deposits of the New Ross - Mahone Bay Area, Nova Scotia, by G. A. O'Reilly, E. J. Farley and M. H. Charest, 96 pages. **$5.00 (Microfiche $1.50)**

Paper ME 1982-1 Geology and Geochemistry of Selected Granitoid Plutons of Cape Breton Island, by S. M. Barr, G. A. O'Reilly and A. M. O'Beirne, 176 pages, 44 figures, 13 tables. **$8.00 (Microfiche $2.00)**

Paper ME 1981-4 Principles of Tectonic Mapping Based upon Plate Tectonic Theory, by J. D. Keppie, 11 pages. **$1.50 (Microfiche $1.00)**

Paper ME 1981-3 The Windsor Group of the Mahone Bay Area, Nova Scotia, by P. S. Giles, 51 pages, figure in back pocket. **$4.00 (Microfiche $1.50)**

Paper ME 1981-2 Major Transgressive - Regressive Cycles in Middle to Late Viséan Rocks of Nova Scotia, by P. S. Giles, 27 pages. **$2.00 (Microfiche $1.50)**

Paper ME 1981-1 The Fisset Brook Formation at Lowland Cove, Inverness County, Nova Scotia, by P. K. Smith and A. S. Macdonald, 18 pages. **$2.00 (Microfiche $1.00)**

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Paper ME 1979-7 Carbonate Banks of the Gays River Formation in Central Nova Scotia, by P. S. Giles, R. C. Boehner and R. J. Ryan, 57 pages, 1 map. **$4.00**

Paper ME 1979-6 Effects of Subsidence and Depositional Environment on the Formation of Lithotypes in a Hypautochthonous Coal of the Pictou Coalfield, by J. H. Calder, 23 pages. **$3.00**

Paper ME 1979-5 Pleistocene Stratigraphy of the Miller Creek Section, Hants County, Nova Scotia, by R. Stea and D. Hemsworth, 16 pages. **$3.00**

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Paper ME 1979-1 Petrology of the Late Precambrian Fourchu Group in the Louisbourg Area, Cape Breton Island, by J. D. Keppie, J. Dostal and J. B. Murphy, 18 pages. **$1.50**

Paper ME 1978-5 Petrology of the Early Silurian Dunn Point and McGillivray Brook Formations, Arisaig, Nova Scotia, by J. D. Keppie, J. Dostal and M. Zentilli, 20 pages. **$1.00**

Paper ME 1978-4 Some Middle Devonian to Lower Carboniferous Rocks of Cape George, Nova Scotia, by J. D. Keppie, P. S. Giles, and R. C. Boehner, 37 pages. **$2.00**

Paper ME 1978-3 Geology of the Giant Lake Area, Southeastern Cape Breton Island, Nova Scotia, by P. K. Smith, 30 pages, 1 map. **$2.00**

Paper ME 1978-2 Age of Igneous Rocks along the Lennox Passage - St. Peter's Lineament, Southern Cape Breton Island, by J. D. Keppie and P. K. Smith, 10 pages. **$1.00**

Paper ME 1978-1 Geology of the Ecum Secum Area, Halifax and Guysborough Counties, Nova Scotia, by D. McBride, 12 pages. **$1.00**

Paper ME 1977-7 Tungsten Mineralization in the Carbonate Rocks of the George River Group, Cape Breton Island, Nova Scotia, by A. K. Chatterjee, 26 pages. **$3.50**

Paper ME 1977-6 Sand and Gravel Resources of Pictou County, by J. H. Fowler and G. B. Dickie, 42 pages, 1 map. **$4.00**

Paper ME 1977-3 Plate Tectonic Interpretation of Paleozoic World Maps (with Emphasis on Circum-Atlantic Orogens and Southern Nova Scotia), by J. D. Keppie, 45 pages. (Reprinted 1982). **$4.00 (Microfiche $1.50)**

Paper ME 1977-1 Tectonics of Southern Nova Scotia, by J. D. Keppie, 34 pages. (Reprinted 1980). **$3.00**

Paper ME 1976-5 Guide to the Invertebrate Fauna of the Windsor Group in Atlantic Canada, by R. G. Moore and R. J. Ryan, 57 pages. **$2.25**

Paper ME 1976-4 Geology, Geochemistry and Mineral Occurrences of the Northeast Margaree River Drainage Basin in parts of Inverness and Victoria Counties, Cape Breton, Nova Scotia, by B. E. MacNabb, J. H. Fowler and T. G. N. Covert, 30 pages, 12 maps. **$15.00**

Paper ME 1976-3 Interpretation of P.P.I. Radar Imagery of Nova Scotia, by J. D. Keppie, 31 pages, 1 map. **$1.25**

Paper ME 1976-2 Geological Data Collection in the Nova Scotia Department of Mines, by J. D. Keppie and A. K. Chatterjee, 15 pages. **$0.50**

Paper ME 1976-1 Structural Model for the Saddle Reef and Associated Veins in the Meguma Group, Nova Scotia, by J. D. Keppie, 34 pages, 2 maps. **$3.00**

REPORTS

Various geoscience publications such as bibliographies, compilations, drill log summaries, indexes, report of activities.

!!!NEW!!!
Report ME 2000-2 Mining Matters for Nova Scotia 2000: Opportunities for Economic Development, edited by D. R. MacDonald, 2000, 42 pages. **$5.00**

!!!NEW!!!
Report ME 2000-1 Minerals and Energy Branch Report of Activities 1999, edited by D. R. MacDonald and K. A. Mills, 2000, 268 pages. **$16.00**

Report ME 1999-2 Mining Matters for Nova Scotia '99: Opportunities for Economic Development, edited by D. R. MacDonald, 1999, 36 pages. **$5.00**

Report ME 1999-1 Minerals and Energy Branch Report of Activities 1998, edited by D. R. MacDonald and K. A. Mills, 1999, 213 pages. **$12.00**

Report ME 1998-2 Mining Matters for Nova Scotia '98: Opportunities for Economic Development, edited by D. R. MacDonald, 1998, 37 pages. **$5.00**

Report ME 1998-1 Minerals and Energy Branch Report of Activities 1997, edited by D. R. MacDonald and K. A. Mills, 1998, 212 pages. **$14.00**

Report ME 1997-1 Minerals and Energy Branch Report of Activities 1996, edited by D. R. MacDonald and K. A. Mills, 1997, 227 pages. **$12.00**

Report ME 1996-3 NTS Location Index to Minerals and Energy Branch Assessment Reports, Contribution Series, Open Files and Publications 1991-1995, by Janette M. Vavra, Norman A. Lyttle and J. Susan Saunders, 1996, 203 pages. **$11.00 (Microfiche $3.00)**

Report ME 1996-2 Author Index to Minerals and Energy Branch Assessment Reports, Contribution Series, Open Files and Publications 1991-1995, by Janette M. Vavra, Norman A. Lyttle and J. Susan Saunders, 1996, 362 pages. **$17.00 (Microfiche: $4.00)**

Report ME 1996-1 Minerals and Energy Branch, Report of Activities 1995, edited by D. R. MacDonald and K. A. Mills, 1996, 99 pages. **$9.00 (Microfiche $2.00)**

Report ME 1995-2 Program and Summaries, Nineteenth Annual Review of Activities, edited by D. R. MacDonald and K. A. Mills, 1995, 71 pages. **$5.00 (Microfiche $2.00)**

Report ME 1995-1 Minerals and Energy Branch, Report of Activities 1994, edited by D. R. MacDonald and K. A. Mills, 1995, 216 pages. **$14.00 (Microfiche $3.00)**

Report ME 1994-2 Program and Summaries, Eighteen Annual Review of Activities, edited by D. R. MacDonald, 1994, 75 pages. **$5.00 (Microfiche $2.00)**

Report ME 1994-1 Mines and Minerals Branch, Report of Activities 1993, edited by D. R. MacDonald, 1994, 245 pages. **$14.00 (Microfiche $3.00)**

Report ME 1993-2 Program and Summaries, Seventeenth Annual Review of Activities, edited by D. R. MacDonald, 1993, 65 pages. **$6.00 (Microfiche $2.00)**

Report ME 1993-1 Mines and Minerals Branch, Report of Activities 1992, edited by D. R. MacDonald and K. A. Mills, 1993, 203 pages. **$12.00 (Microfiche $3.00)**

Report ME 1992-2 NTS Location and Author Index to Nova Scotia Department of Natural Resources, Mines and Energy Branches Assessment Reports, Contribution Series, Open Files and Publications for 1991, by Janette M. Vavra and Norman A. Lyttle, 1992, 178 pages. **$14.00 (Microfiche $3.00)**

Report ME 1992-1 Mines and Minerals Branch, Report of Activities 1991, ed. D. R. MacDonald, 1992, 122 pages. **$7.00 (Microfiche $2.00)**

Report ME 1991-4 Subject Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 5630 pages. **(Microfiche only $5.00)**

Report ME 1991-3 Author Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 508 pages. **$20.00 (Microfiche $5.00)**

Report ME 1991-2 NTS Location Index to Nova Scotia Department of Mines and Energy Assessment Reports, Open Files, Publications and Theses 1981-1990, by Norman A. Lyttle and Janette M. Freeman, 1991, 452 pages. **$20.00 (Microfiche $5.00)**

Report ME 1991-1 Mines and Minerals Branch, Report of Activities 1990, ed. D. R. MacDonald, 1991, 140 pages. **$8.00 (Microfiche $3.00)**

Report ME 1990-1 Mines and Minerals Branch, Report of Activities 1989, Part B, ed. D. R. MacDonald, 1990, 112 pages. **$7.00 (Microfiche $2.00)**

Report ME 1989-1 Mines and Minerals Branch, Report of Activities 1988, Part B, eds. Y. Brown and D. R. MacDonald, 1988, 133 pages. **$9.00 (Microfiche $2.00)**

Report ME 1988-1 Mines and Minerals Branch, Report of Activities 1987, Part B, eds. D. R. MacDonald and Y. Brown, 292 pages. **$20.00 (Microfiche $4.00)**

Report ME 1987-4 Drilling Logs of Government Core Drills 1986, compiled by C. Kavanaugh, 1987, 64 pages. **$5.00 (Microfiche $2.00)**

Report ME 1987-2 Gold in Nova Scotia: A Bibliography of the Geology, and Exploration and Mining Histories from 1832 to 1986, by Janet Gillespie-Wood, 1986, 500 pages. **$25.00 (Microfiche $3.00)**

Report ME 1987-1 Mines and Minerals Branch, Report of Activities 1986, eds. J. L. Bates and D. R. MacDonald, 270 pages. **$15.00 (Microfiche $3.00)**

Report ME 1986-3 Drilling Logs of Government Core Drills 1985, compiled by I. MacDougall and D. E. Polley, 1986, 21 pages. **$3.50 (Microfiche $2.00)**

Report ME 1986-1 Mines and Minerals Branch, Report of Activities 1985, ed. J. L. Bates, 374 pages. **$12.00 (Microfiche $3.50)**

Report ME 1985-4 Drilling Logs of Government Core Drills 1984, compiled by I. MacDougall and D. E. Polley, 1984, 32 pages. **$3.50 (Microfiche $2.00)**

Report ME 1985-1 Mines and Minerals Branch, Report of Activities 1984, eds. K. A. Mills and J. L. Bates, 232 pages. **$10.00 (Microfiche $3.00)**

Report ME 1984-6 Bibliography of the Surficial Geology of Nova Scotia and the Offshore (with Radiocarbon Date List), by R. R. Stea and V. J. Brisco, 128 pages. **$6.00 (Microfiche $2.00)**

Report ME 1984-5 Drilling Logs of Government Core Drills 1983, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. **$3.50 (Microfiche $2.00)**

Report ME 1984-4 Keyword Index to Theses in Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. **(Microfiche only $5.00)**

Report ME 1984-1 Mines and Minerals Branch, Report of Activities 1983, eds. J. Szostak and K. A. Mills, 352 pages. **$10.00 (Microfiche $4.00)**

Report ME 1983-3 Drilling Logs of Government Core Drills 1982, compiled by I. MacDougall and D. E. Polley, 1983, 38 pages. **$3.50 (Microfiche $2.00)**

Report ME 1983-1 Mines and Minerals Branch, Report of Activities 1982, ed. K. A. Mills, 404 pages. **$10.00 (Microfiche $3.50)**

Report ME 1982-7 Uranium in Nova Scotia: A Background Summary for the Uranium Inquiry, Nova Scotia, 122 pages, 2 maps. Out of Print **(Microfiche only $2.00)**

Report ME 1982-6 Drilling Logs of Government Core Drills 1981, compiled by I. MacDougall and D. E. Polley, 1982, 60 pages. **$3.50 (Microfiche $1.50)**

Report ME 1982-5 Keyword Index to Geological Survey of Canada Documents on Nova Scotia to 1980. **(Microfiche only $2.00)**

Report ME 1982-4 Keyword Index to Open File Reports in Nova Scotia Department of Mines and Energy Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. **(Microfiche only $1.00)**

Report ME 1982-3 Keyword Index to Publications in Nova Scotia Department of Mines and Energy Report ME 1981-6, by N. A. Lyttle and J. Gillespie-Wood. **(Microfiche only $2.00)**

Report ME 1982-1 Mineral Resources Division, Report of Activities 1981, ed. K. A. Mills, 139 pages. **$7.00 (Microfiche $2.00)**

Report ME 1981-7 Index to Drillhole and Well Data 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 127 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-6 Index to Publications, Open File Reports and Theses, 1862-1980, by N. A. Lyttle and J. Gillespie-Wood, 222 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-5 Keyword Index to Assessment Reports 1864-1980, by N. A. Lyttle and J. Gillespie-Wood. **(Microfiche only $5.00)**

Report ME 1981-4 Index to Assessment Reports 1864-1980, by N. A. Lyttle and J. Gillespie-Wood, 109 pages. **$10.00 (Microfiche $3.00)**

Report ME 1981-3 Drilling Logs of Government Core Drills 1980, compiled by I. MacDougall and D. E. Polley, 52 pages. **$3.50 (Microfiche $1.00)**

Report ME 1981-2 Compilation of Igneous Chemical Analyses from Nova Scotia, up to 1978, compiled by J. D. Keppie, P. K. Smith and M. A. K. Grice, 114 pages. **$4.00 (Microfiche $2.00)**

Report ME 1981-1 Mineral Resources Division, Report of Activities 1980, ed. K. A. Mills, 199 pages. **$8.00 (Microfiche $2.00)**

Report ME 1980-3 Drilling Logs of Government Core Drills 1979, compiled by I. MacDougall and D. E. Polley, 68 pages. **$3.50 (Microfiche $1.50)**

Report ME 1980-2 Index to Drilling Logs of Government Core Drills 1972-78, by N. A. Lyttle and J. Gillespie-Wood, 47 pages. **$3.00**

Report ME 1980-1 Mineral Resources Division, Report of Activities 1979, 248 pages. **$7.00**

Report ME 1979-2 Drilling Logs of Government Core Drills 1978, by I. MacDougall and D. E. Polley, 54 pages. **$2.00**

Report ME 1979-1 Mineral Resources Division, Report of Activities 1978, 177 pages. **$6.00**

Report ME 1978-4 Compilation of Isotopic Age Data of Nova Scotia, by J. D. Keppie and P. K. Smith, 54 pages, 7 maps. **$7.00**

Report ME 1978-2 Drilling Logs of Government Core Drills 1977, by I. MacDougall and D. E. Polley, 72 pages. **$2.00**

Report ME 1978-1 Mineral Resources Division, Report of Activities 1977, 104 pages. **$4.00**

Report ME 1977-3 Drilling Logs of Government Core Drills 1976, by I. MacDougall and D. W. Grimm, 33 pages. **$1.00**

Report ME 1977-1 Mineral Resources Division, Report of Activities 1976, 207 pages. **$10.00**

Report ME 1976-3 Drilling Logs of Government Core Drills 1975, by I. MacDougall and D. W. Grimm, 47 pages. **$1.00**

Report ME 1976-2 Mineral Resources Division, Report of Activities 1975, 145 pages. **$3.00**

Report ME 1976-1 Drilling Logs of Government Core Drills, 1974, by I. MacDougall and D. W. Grimm, 73 pages. **$1.00**

Report ME 1975-1 Report of Activities of the Mineral Resources and Geological Services Division, 1974, by Nova Scotia Department of Mines, 75 pages. **$1.00**

SAMPLE CATALOGUES

Bound volumes containing rock or mineral commodity samples.

SC ME 1989-1 Nova Scotia Dimension Stone for Designers, Developers and Quarriers, 1989 (Comprehensive catalogue of 11 Nova Scotia building stones, includes actual sample tiles plus Information Series ME 19). **$100.00**

Appendix 3

Minerals and Energy Branch Digital Geoscience Data for Sale

DIGITAL COLLECTIONS	FORMAT	SIZE/MEDIA	PRICE
DC001. Complete set of Nova Scotia Department of Natural Resources digital geoscience data, version 3, 2000	E00, DXF/ DBF, TIFF, SHP	377 Mb (compressed), (for individual products, see below) 1 CD-ROM	$10.00
MAPS	FORMAT	SIZE/MEDIA	PRICE
D00-01. Geological Map of the Province of Nova Scotia, Version 1, 2000, compiled by J. D. Keppie, scale 1:500 000. An image of the published map and legend (Map ME 2000-1) is also available in PDF format.	E00 DXF/DBF, SHP	5 Mb 6 Mb 6 Mb	
D94-08. Geological Map of Bridgetown, Nova Scotia [21A/14], [1:5000], version 1, 1997, compiled by M. A. MacDonald and L. J. Ham, 1994 (line work only, no point data)	E00 DXF/DBF	360 Kb 587 Kb	
D94-07. Geological Map of Digby, Nova Scotia [21A/12], 1:50 000, version 1, 1997, compiled by L.J. Ham, 1994 (line work only, no point data)	E00 DXF/DBF	373 Kb 493 Kb	
D94-04. Geological Map of Weymouth, Nova Scotia [21A/05], version 1, 1997, compiled by M.A. MacDonald and L. J. Ham, 1994, scale 1:50000 (line work only, no point data)	E00 DXF/DBF	106 Kb 200 Kb	
D94-03. Geological Map of Wentworth Lake, Nova Scotia [21A/04 and parts of 20P/13], version 1, 1997, compiled by L. J. Ham and M. A. MacDonald, 1994, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	156 Kb 243 Kb	
D94-02. Geological Map of Lake Rossignol, Nova Scotia [21A/03 West], version 1, 1997, compiled by M. C. Corey and R. J. Horne, 1994, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	76 Kb 88 Kb	
D94-01. Geological Map of the South Mountain Batholith, Western Nova Scotia [parts of 11D and 21A], version 1, 1997, compiled by M. A. MacDonald, 1994, scale 1:250 00 (line work only, no point data)	E00 DXF/DBF	1.5 Mb 1.6 Mb	

MAPS (cont.).	FORMAT	SIZE/MEDIA	PRICE
D92-03. Surficial Geology Map of the Province of Nova Scotia, version 1, 1997, compiled by R. R. Stea, H. Conley and Y. Brown, 1992, scale 1:500 000.	E00 DXF/DBF	20 Mb 22Mb	
D90-14. Cumberland Basin Geology Map Tatamagouche and Malagash, Cumberland, Colchester and Pictou Counties, Nova Scotia [11E/11 and 11E/14 south], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	400 Kb 458 Kb	
D90-13. Cumberland Basin Geology Map Oxford and Pugwash, Cumberland County, Nova Scotia [11E/12 and 11E/13], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	600 Kb 763 Kb	
D90-12. Cumberland Basin Geology Map Amherst, Springhill and Parrsboro, Cumberland County, Nova Scotia [21H/08, 21H/09 and 21H/10], version 1, 1997, compiled by R. J. Ryan, R. C. Boehner, A. J. Deal and J. H. Calder, 1990, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	500 Kb 600 Kb	
D90-11. Cumberland Basin Geology Map, Apple River and Cape Chignecto, Cumberland County, Nova Scotia [21H/07 and 21H/10], version 1, 1997, compiled by R. J. Ryan and R. C. Boehner, 1990, 1:50 000 (line work only, no point data)	E00 DXF/DBF	300 Kb 408 Kb	
D86-02. Geological Map of the Windsor Area, Nova Scotia [21A/16 north and 21H/01 south], version 1, 1997, compiled by R. G. Moore and S. A. Ferguson, 1986, 1:25 000 (line work only, no point data)	E00 DXF/DBF	864 Kb 832 Kb	
D86-01. Geological Map of the Sydney Basin-Cape Breton, Nova Scotia [11K/01, 11K/08 and 11J/04], version 1, 1997, compiled by R. C. Boehner and P. S. Giles, 1986, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	1.2 Mb 1.6 Mb	
D85-02. Geology of Loch Lomond Basin and Glengarry Half Graben, Nova Scotia [11F/15 east and 11F/16 west], version 1, 1997, compiled by R. C. Boehner and G. Prime, 1985, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	500 Kb 610 Kb	
D85-01. Industrial Mineral Commodities Map of the Province of Nova Scotia, version 1, 1997, compiled by J. H. Fowler, 1985, scale 1:500 000.	E00 DXF/DBF	200 Kb 200 Kb	
D84-02. Geological Map of the Boisdale Peninsula, Central Cape Breton Island, Cape Breton County, Nova Scotia [parts of 11F/15, 11F/16, 11K/01 and 11K/02], version 1, 1997, compiled by S. M. Barr and J. R. D. Setter, 1984, scale 1:100 000 (line work only, no point data)	E00 DXF/DBF	258 Kb 371 Kb	

MAPS (cont.).	FORMAT	SIZE/MEDIA	PRICE
D83-05. Metallogenic Map of Nova Scotia, version 1, 1997, compiled by A. K. Chatterjee, 1983, scale 1:500 000 (includes the inset map **Metallogenic Associations and Domains of Silver,** scale 1:1 000 000).	E00 DXF/DBF	4 Mb 6 Mb	
D83-01. Geological Map of the Hantsport Area, Nova Scotia [21H/01], version 1, 1997, compiled by S. A. Ferguson, 1983, scale 1:25 000 (line work only, no point data)	E00 DXF/DBF	459 Kb 609 Kb	
D82-09. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 4 of 4 [11E/06, 11E/07 west and 11E/10 west], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	600 Kb 649 Kb	
D82-08. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 3 of 4 [11E/05 and 11E/12], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	500 Kb 690 Kb	
D82-07. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 2 of 4 [21H/08 and 21H/09], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	600 Kb 650 Kb	
D82-06. Geological Map of the Cobequid Highlands-Colchester, Cumberland and Pictou Counties, Nova Scotia, sheet 1 of 4 [21H/07], version 1, 1997, compiled by H. V. Donohoe Jr. and P. I. Wallace, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	400 Kb 391 Kb	
D82-05. Geology Map of the Northern Antigonish Highlands, Nova Scotia [11E/09, 11E/16, 11F/12 and 11F/13], version 1, 1997, compiled by J. B. Murphy, J. D. Keppie and A. H. Hynes, 1991, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	38 Kb 38 Kb	
D82-04. Geological Map of the Shubenacadie and Musquodoboit Basins, Central Nova Scotia [11D/13, 11D/14, 11E/02 west, 11E/04 east and 11E/03], version 1, 1997, compiled by P. S. Giles and R. C. Boehner, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF.DBF	1 Mb 1.4 Mb	
D82-03. Geological Map of the Eureka Area, Central Nova Scotia [11E/07D and 11E/10A], version 1, 1997, compiled by P. S. Giles, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	200 Kb 195 Kb	

MAPS (cont.).	FORMAT	SIZE/MEDIA	PRICE
D82-02. Geological Map of the Antigonish Basin, Nova Scotia [parts of 11E/09, 11F/12 and 11F/13], version 1, 1997, compiled by R. C. Boehner and P. S. Giles, 1982, scale 1:50 000 (line work only, no point data)	E00 DXF/DBF	691 Kb 920 Kb	
D79-03. Bouguer Gravity Anomaly Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:500 000.	E00 DXF/DBF	1 Mb 2 Mb	
D79-01S. Structural Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:1 000 000 (insert from Map 79-1)	E00 DXF/DBF	1 Mb 1.5 Mb	
D79-01M. Metamorphic Map of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:1 000 000 (insert from Map 79-1)	E00 DXF/DBF	700 Kb 1 Mb	
D79-01. Geological Map of the Province of Nova Scotia, version 1, 1997, compiled by J. D. Keppie, 1979, scale 1:500 000 (does not include the 1:1 000 000 structural and metamorphic inset maps).	E00 DXF/DBF	5 Mb 6 Mb	
D1752a. Geological map of northern Cape Breton Island, Nova Scotia [11K/02, 11K/03, 11K/06 to 11K/16, 11N/01, 11N/02] [1:100 000], version 1, 1997, compiled by S. M. Barr, R. A. Jamieson, R. P. Raeside, 1992, Geological Survey of Canada, Map 1752a.	E00 DXF/DBF	2 Mb 2Mb	
DP 001a. Mineral occurrence query program, version 2, 1997. (This is a viewing and searching program with instructional manual (40 pages) for use with DP 001b Mineral Occurrence Database)	EXE	3 Mb	
DP 001b. Mineral occurrence database, version 3, 1998. This database can be used with DP 001a, the Mineral Occurrence Query Program.	DBF	7 Mb	
DP 002. Mineral occurrence database, version 3, 1998.	E00 DXF/DBF	4 Mb 7 Mb	
DP 003. Drillholes database, version 2, 2000.	E00 DXF/DBF SHP	55 Mb 16 Mb 55 Mb	
DP 004. Regional geochemical datasets (biogeochemical, lake and stream sediment, lake and stream water, soil, rock and till geochemical surveys), version 1, 1996.	E00 DXF/DBF	24 Mb 19 Mb	
DP 009. Claim reference map grid, Nova Scotia, version 2, 2000.	E00 DXF/DBF SHP	1.4 Kb 1.2 Kb 1.0 Mb	
DP 010. Abandoned mine openings database, version 2, 2000.	E00 DXF/DBF SHP	4 Mb 3 Mb 4 Mb	

MAPS (cont.).	FORMAT	SIZE/MEDIA	PRICE
!!!NEW!!! **DP 012. Claim, mining tract and petroleum reservations grids for claim reference maps, Nova Scotia,** version 1, 2000. (distributed by 1:50 000 NTS map sheet)	DXF/DBF SHP	3.6 Mb 3.9 Mb	
DP 005. Airborne gamma ray spectrometric survey images, elemental and elemental ratio images covering 11D, 11E, 11F, 11G, 11J, 11K, 11N, 20O, 20P, 21A, 21B and 21H), version 1, 1997 (250 m x 250 m resolution).	TIFF	14 Mb	
DP 006. Airborne magnetometer survey images, total field and vertical gradient images covering 11D, 11E, 11F, 11G, 11J, 11K, 11N, 20O, 20P, 21A, 21B and 21H, version 1, 1997 (250 m x 250 m resolution).	TIFF	8 Mb	
DP 007. Airborne synthetic aperture radar (SAR) images covering 11D, 11E/01, 11E/02, 11E/03 and 11E/04, version 1, 1997, (6 images, 25 m x 25 m resolution).	TIFF	59 Mb, CD-ROM	$10.00
DP 008. Meguma Terrane enhanced second vertical derivative aeromagnetic digital data, version 1, 1997. Includes: (a) images in TIFF format of the aeromagnetic data f rom OFM's 97-7 to 97-28 and 97-30 to 97-33, without topographic base information or legends; (b) contractor's report on the processing methodology; (c) plot files in HP-GL/2 format of OFM's 97-7 to 97-28 and 97-30 to 97-33.	TIFF	573 Mb, CD-ROM	$10.00
DP 011 Enhanced Aeromagnetic and Digital Elevation Image of Eastern Nova Scotia, Version 1, 2000, M. S. King, (25 m x 25 m, 40 m x 40 m, 80 m x 80 m resolutions) (TIFF Format).	TIFF	100 Mb/14 Mb/5 Mb, CD-ROM	$10.00